



United States Steel Corporation
Penn Liberty Plaza 1
1350 Penn Ave – Suite 200
Pittsburgh, PA 15222-4211
412 433 5916
Email: twoodwell@uss.com

Tishie Woodwell
Acting General Manager
Environmental Affairs

VIA HAND DELIVERY

March 3, 2015

Mr. Peter Ramanauskas
U. S. Environmental Protection Agency - Region 5
77 West Jackson Blvd. (LU-9J)
Chicago, IL 60604

**Re: Self-implementing Cleanup and Disposal of PCB Remediation Waste
Former Birmingham Steel Joliet Works 50-acre Facility
Joliet, Will County, Illinois
ILD005454566**

Dear Mr. Ramanauskas:

This letter is being sent to request Approval under Title 40: Protection of Environment, Code of Federal Regulation (CFR) Section 761.61(a), for self-implementing cleanup and disposal of polychlorinated biphenyls (PCB) remediation waste from the Former Birmingham Steel Joliet Works Facility in Joliet, Illinois (Facility). Enclosed is one hard copy of *Revised Self-Implementing Remediation Work Plan for PCB Impacted Areas* (Revised PCB Work Plan). The PCB Work Plan submitted on January 30, 2015 has been revised to incorporate preliminary comments provided by the United States Environmental Protection Agency (USEPA) and subsequent communications between Jennifer Dodd of USEPA and Kevin Stetter of the United States Steel Corporation (USS). USS is in the process of securing a contractor that will be performing the remediation work. Once the contractor is identified, their representative will sign the certification form and submit to USS. USS will then append the work plan with the additional certification.

The former Birmingham Steel Corporation's Joliet Works Facility consists of approximately 57 acres and has been divided into two parcels for investigation under Illinois Environmental Protection Agency's (IEPA's) Site Remediation Program (SRP) – a 50-acre parcel ("Site", located to the east of the Canadian National Railway tracks) where historical steel-making facilities were located) and an adjacent 7-acre parcel (located to the west of the Canadian National Railway tracks) where the waste water treatment plant is located.

On June 17, 2005, USS, the current Site owner, entered the entire 57-acre Site into the SRP. The official SRP Site name is Birmingham Steel Corporation. It is currently active as LPC#: 1970450024 and United States Environmental Protection Agency (USEPA) ID is ILD005454566. The SRP Remedial Applicant is USS and the current point of contact

is Mr. Mark Rupnow at 1350 Penn Ave., Suite 200, Pittsburgh, PA, 15222. USS intends to obtain a Comprehensive No Further Remediation (NFR) letter for the Site through the SRP. The IEPA Remedial Project Manager is Mr. Tim Murphy.

USS desires to ensure that remediation activities at the PCB-impacted areas are performed in a timely manner, consistent with the schedule and technical requirements developed in the *Remedial Action Plan*, approved by IEPA on November 26, 2014, as well as in accordance with applicable Toxic Substance Control Act (TSCA) requirements.

USS is looking forward to working with you and with members of your TSCA group as a team to complete the remedial measures at the PCB-impacted areas, using this Approval. If you have further questions or comments, please contact Mr. Kevin Stetter at (219) 888-3449.

Sincerely,



Tishie Woodwell

Enclosures

cc	M. R. Rupnow	(w/ encl.)
	K. T. Stetter	(w/ encl.)
	A. G. Thiros	(w/ encl.)
	D. J. Zywan	(w/ encl.)
	J. L. Rey	(w/ encl.)
	P. F. Hurst (AECOM)	(w/ encl.)

Certification

In accordance with 40 CFR, 761.61(a)(1)(3)(E), I certify that, as a responsible corporate officer of U. S. Steel (USS), all sampling plans, sample collection procedures, sample preparation procedures, extraction procedures, and instrumental/chemical analysis procedures used to assess or characterize the PCB impacts at the Site (located at 927 Collins Street in Joliet, Illinois) are on file at the Environmental Department of U. S. Steel Gary Works in Gary , IN, and are available for EPA inspection.

Signature:

Tishie Woodwell

Name:

Tishie Woodwell

Title:

Acting General Manager, Environmental Affairs

Date:

March 3, 2015

**Former Birmingham Steel Corporation
Joliet Works 50-acre Facility
Revised Self-Implementing Remediation Work Plan for
PCB Impacted Area
Joliet, Illinois**

Prepared for:



March 2015



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LIST OF ACRONYMS/ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
°C	Centigrade
CEC	Civil & Environmental Consultants, Inc
CFR	Code of Federal Regulation
cm	Centimeter
cm ²	Centimeter Square
CSI	Comprehensive Site Investigation
EBK	Sample Code for Equipment Blank
E&E	Environment and Ecology
ESA	Environmental Site Assessment
ESI	Expanded Site Inspection
FBK	Sample Code for Field Blank
FD	Sample Code for Field Duplicate
FID	Flame Ionization Detector
FSIP	Focused Site Inspection Prioritization
HASP	Health and Safety Plan
HRS	Hazard Ranking System
IAC	Illinois Administrative Code
IDW	Investigation-Derived Waste
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
JULIE	Joint Underground Locating Information for Excavators
Kg	Kilogram
Mg	Milligram
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NAPL	Non-Aqueous Phase Liquid
NELAC	National Environmental Laboratory Accreditation Conference
NFR	No Further Remediation
OSHA	Occupation Safety and Health Administration



PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
PPE	Personal Protection Equipment
ppm	Parts per Million
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RO	Remediation Objective
SB	Sample Code for Subsurface Soil
SI	Sample Code for Self-Implementing
SOP	Standard Operating Procedure
SRP	Site Remediation Program
SS	Sample Code for Surface Soil
SSI	Supplemental Site Investigation
TPH	Total Petroleum Hydrocarbon
TSCA	Toxic Substance Control Act
µg	Microgram
URS	URS Corporation
USEPA	United States Environmental Protection Agency
USS	U.S. Steel Corporation
VS	Sample Code for Verification Sample
WTI	Waste Technology, Inc.
yd ³	Cubic Yards



1.0 INTRODUCTION

This work plan is prepared to implement part of the approved *Remedial Action Plan* (RAP, URS, 2014c) focusing on remediation of the polychlorinated biphenyls (PCBs) at the Central Parcel (*i.e.*, Remediation Areas 8, 9 and 10) within the 50-acre parcel (Site). Remediation of total petroleum hydrocarbon (TPH) impacts at Areas 1 through 7 of the RAP will be addressed with the Illinois Environmental Protection Agency (IEPA) separately at the Former Birmingham Steel Corporation Joliet Works Facility at 927 Collins Street in Joliet, Illinois (Facility). Site locations and layout are shown in **Figure 1** and **Figure 2**, respectively.

To facilitate the decision-making process regarding the investigation and remediation activities, the Site has been divided into four subareas based on the historical land use, nature and extent of impacts, and potential for exposure (*i.e.*, the Central Parcel, East Parcel, Northwest Parcel, and South Parcel). The laboratory analytical results of samples collected during previous investigations indicated the presence of PCBs in soil at a few areas within the Central and South Parcels of the Site.

United States Steel Corporation (USS) has prepared this work plan to conduct excavation of impacted soil and post-excavation verification sampling for PCBs for the Central Parcel. The South Parcel will be addressed in a separate work plan following further characterization. USS hereby submits this work plan to USEPA for review and approval.

1.1 Overview

The Facility consists of approximately 57 acres and has been divided into two parcels for investigation under IEPA's Site Remediation Program (SRP, [IPCB, 2004]): the Site (*i.e.*, a 50-acre parcel located to the east of the Canadian National Railway tracks) where historical steel-making facilities were located) and an adjacent 7-acre parcel (located to the west of the Canadian National Railway tracks) where the waste water treatment plant is located. Industrial activities at the Site ceased in 2000. The Site currently consists of buildings, areas paved with asphalt, concrete or gravel, and open areas interspersed with sparse vegetation. Except for the small Guard Trailer at the 927 Collins Street front entrance that is used by a contract security company and a part-time employee who performs administrative duties, all other buildings are vacant and not used for any purposes.

USS, the current Facility owner, entered the entire 57-acre into the IEPA's SRP on June 17, 2005. The official SRP name is Birmingham Steel Corporation. It is currently active as LPC#: 1970450024 and United States Environmental Protection Agency (USEPA) ID is ILD005454566. The SRP Remedial Applicant is USS and the current point of contact is Mr. Mark Rupnow at 1350 Penn Ave., Suite 200, Pittsburgh, PA, 15222. USS intends to obtain a Comprehensive No Further Remediation (NFR) letter for the Facility through the SRP. The IEPA Remedial Project Manager is Mr. Tim Murphy.



USS is in the process of preparing the Site for future redevelopment. For planning purposes, it was assumed that the Site would be re-developed for industrial/commercial use. USS will post a deed restriction on the property as an institutional control measure, per Illinois Administrative Code (IAC) 742.1000, to ensure that the future use of the Site will be limited to industrial and/or commercial use.

USS plans to address PCB-impacted areas at the Site using the Self-Implementing Cleanup and Disposal of PCB Remediation Waste option, as provided in 40 Code of Federal Regulation (CFR) 761.61(a).

1.2 Objective

The objective of the remediation is to remove the PCB impacted soils from the Site by excavation and conduct post-excavation verification sampling activities for PCBs to verify attainment of the following remediation objectives (ROs):

- Central Parcel
 - **Remediation Area 8:** An RO of less than or equal to 1 milligram (mg) PCBs per 1 kilogram (kg) soil (≤ 1 mg/kg, or ≤ 1 part per million [ppm]) for PCB-impacted areas at the Central Parcel by the front gate to the Site, based on the cleanup level for high occupancy areas per 40 CFR 761(a)(4)(i)(A)..
 - **Remediation Area 9:** An RO of less than or equal to 1 mg PCBs per 1 kg soil (≤ 1 mg/kg, or ≤ 1 ppm) for the remaining PCB-impacted areas at the Central Parcel, based on the cleanup level for high occupancy areas.
 - **Remediation Area 10:** Total PCB concentration was reported at 1.4 mg/kg in a sludge sample (X131) collected by IEPA in 2004 (**Section 2.3.3.2**). This location will be inspected and sludge material will be removed, if present. See **Section 2.6** and **Section 2.8** for planned procedures for this area.

1.3 Report Organization

The remainder of this report consists of five sections.

- **Section 2** presents the remedial approach that will be implemented at the Site in accordance with applicable regulations as specified in 40 CFR 761.61(a) and field procedures presented in the approved RAP.
- **Section 3** presents health and safety considerations for the project.
- **Section 4** describes documentations that will be generated during the implementation of field activities and at the completion of the project.
- **Section 5** presents schedule of implementation.



- **Section 6** presents references used to develop this work plan.



2.0 REMEDIAL APPROACH

For the purpose of this work plan, an impacted location is defined as a location with PCB concentrations greater than 1 mg/kg in soil. Information presented in this section is organized in accordance with requirements as specified in 40 CFR 761.61(a).

2.1 Applicability

The selected self-implementing cleanup option is applicable for addressing PCB-impacted areas at the Site based on rules described in 40 CFR 761.61(a)(1).

- According to 40 CFR 761.61(a)(1)(i), the self-implementing cleanup and disposal of PCB remediation waste approach cannot be used to clean up the following areas:
 - Surface water or groundwater.
 - Sediments in marine and freshwater ecosystems.
 - Sewers or sewage treatment systems.
 - Any private or public drinking water sources or distribution systems.
 - Grazing lands.
 - Vegetable gardens.

As indicated in **Section 1**, this work plan focuses on the remediation of PCBs in soil at a former industrial facility and not for locations listed in 40 CFR 761.61(a)(1)(i).

- According to 40 CFR 761.61(a)(1)(ii), the self-implementing cleanup and disposal of PCB remediation waste approach will not be binding upon cleanups conducted under other regulatory authorities (e.g., the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA], or the Resource Conservation and Recovery Act [RCRA]).

As indicated in **Section 1**, the Site is unregulated and investigative and remedial activities are being conducted on a voluntary basis under IEPA's SRP.

2.2 Site Characterization

According to 40 CFR 761.61(a)(2), any person conducting self-implementing cleanup of PCB remediation waste must characterize the site adequately to be able to provide information required by 40 CFR 761.61(a)(3).

The requirement as specified in 40 CFR 761.61(a)(2) is met because the nature and extent of impacts at the Site have been delineated based on results of the following evaluations and investigations. Detailed information regarding results of previous investigations is presented in Appendix B of the *Remediation Objectives Report (ROR)*, dated July 2013.



- **1989/Screening Site Inspection by USEPA's contractor Ecology & Environment, Inc. (E&E).** The inspection included an interview with a Site representative, a reconnaissance inspection of the Site, and the collection of eight soil samples from the Site and surrounding areas. Shallow soil samples were collected from approximately zero to one-half foot below ground surface. The E&E *Screening Site Inspection* report was submitted to USEPA on October 2, 1990 (E&E, 1990).
- **1995/CERCLA Site Inspection Prioritization Report by IEPA (IEPA, 1995).** The IEPA conducted sampling on May 23 and May 24, 1995 as part of a CERCLA focused site inspection prioritization (FSIP) of the Site. The FSIP consisted of soil sampling at the Site and soil and sediment sampling from areas surrounding the Site.
- **1996/Site Evaluation by the Illinois Department of Public Health (IDPH).** IDPH's findings are reported in the *Health Assessment State Initial Site Evaluation* (dated September 11, 1996). The Site evaluation included a review of previous investigations and Site reconnaissance.
- **2002/Phase I Environmental Site Assessment (ESA) by Hart Crowser for USS.** A Phase I ESA was conducted in general accordance with American Society for Testing and Materials (ASTM) guidelines E1527-00. Results of the Phase I ESA are reported in the November 21, 2002, *Phase I Environmental Site Assessment Birmingham Steel Mill, 927 Collins Street Joliet, Illinois*.
- **2003 and 2004/Preliminary Site Investigations by Waste Technology, Inc. (WTI) for USS.** WTI conducted a preliminary site investigation in 2003 for USS that included excavation of sixteen soil test pits, installation of four monitoring wells, soil and groundwater sampling, and analytical testing. The results of the preliminary investigation are presented in a November 2003 report titled *Phase I Environmental Investigation*. WTI conducted a second site investigation in 2004 that included additional soil test pits, soil sampling, and analytical testing. The findings of the second investigation performed by WTI are presented in a May 2004 report titled *Phase II Environmental Investigation*.
- **2004/Expanded Site Investigation (ESI) by IEPA.** The results are presented in the September 23, 2004 report titled *CERCLA Expanded Site Inspection*. This investigation included soil, free-phase hydrocarbon, and groundwater sampling and analyses and was completed primarily for CERCLA Hazardous Ranking System (HRS) purposes and not for Site characterization purposes.
- **2006 to 2008/Comprehensive Site Investigation (CSI) by Civil & Environmental Consultants, Inc. (CEC) for USS.** The CSI was performed in two phases to verify and supplement previous work completed by the IEPA and WTI. The Phase I of the CSI



commenced in November 2006, while the Phase II portions of the CSI were performed in November 2007. Additional sampling to supplement the initial investigation and provide quarterly groundwater data was completed in February 2008 and May 2008. CSI activities included the collection of soil and groundwater samples for chemical analyses.

- Collection of surface soil samples from 58 surface grid locations and subsurface soil samples from 82 soil borings. Soil borings were advanced to the bedrock surface at all locations through overburden fill consisting of silty sands, gravels, slag, and mill scale.
- Collection of groundwater samples from eight shallow and four deep monitoring wells. Data obtained from the wells was used to prepare potentiometric maps, which show groundwater flowing in west to southwesterly direction.

Results of the CSI are presented in the *Comprehensive Site Investigation Report* (CSIR, 2008) and the ROR (URS, 2008).

- ***December 2008 and March 2009/Groundwater Sampling by URS Corporation (URS) for USS.*** Groundwater samples were collected from all monitoring wells at the Facility for laboratory analyses. Results of analytical data from wells at the 50-acre parcel are presented in the Revised Final ROR, dated March 2014 (URS, 2014a).
- ***February 2012/Groundwater Gauging by URS for USS.*** Field activities were conducted to measure water levels and observe for the presence/absence of free phase materials at all wells at the Facility. Information compiled from these activities is presented in the Revised Final ROR (URS, 2014a).
- ***2013/Supplemental Site Investigation (SSI) by URS for USS.*** The SSI was performed to achieve the following objectives as agreed upon during the November 13, 2012 meeting between IEPA and USS.
 - Further characterizing the vertical and horizontal extent of soil impacted areas, including PCBs, TPH, and polycyclic aromatic hydrocarbons, identified in previous investigations.
 - Evaluating if groundwater downgradient of the TPH area is impacted.
 - Evaluating groundwater data collected by IEPA to determine if additional sampling is warranted.
 - Evaluating the current groundwater conditions.



- **2014/ ROR for Three Subareas at the 50-Acre Parcel.**

- The Revised Final ROR (first submitted in October 2008, and subsequently revised in April 2012, July 2012, July 2013, and March 2014) was approved on May 30, 2014.

The *Addendum to the Revised Remediation Objectives Report* (URS, 2014b) was submitted to the IEPA on August 20, 2014 to provide information requested in IEPA's conditional approval letter, dated May 30, 2014. The *Addendum to the Revised Remediation Objectives Report* was approved on October 22, 2014.

- The Revised Final ROR (dated March 2014) and the *Addendum to the Revised Remediation Objectives Report* (dated August 2014) provide documentation to support the ROs selected for the Site.

- **2014/Remedial Action Plan for Three Subareas at the 50-Acre Parcel.**

- An RAP (URS, 2014c), submitted to IEPA on October 13, 2014 was approved on November 26, 2014. The RAP describes the cleanup activities to be implemented at the Site to meet the ROs.

2.3 Remedial Approach

This section presents the remedial approach that will be implemented to address PCB impacted soil at the Site to meet requirements specified in 40 CFR 761.61(a)(3).

- **Section 2.3.1** presents the nature of PCB detected in soil at the Site.
- **Section 2.3.2** presents the procedures used to sample PCBs in previous investigations.
- **Section 2.3.3** presents the location and extent of PCB impacts identified at the Site.
- **Section 2.3.4** presents a plan for addressing PCB impacts in soil.

2.3.1 Nature of PCB Impact

PCBs detected in soil samples are likely to be related to transformers which contained PCBs that were used at the Site. It is reported in the Phase I ESA report (Hart Crowser, 2002) that a number of transformers were observed during the site visit conducted in 2002 and, according to interviews with onsite personnel, transformers have been tested for PCBs and the fluid in PCB-containing units had been replaced or the entire units were replaced by September 1997. The existing transformers contain less than 50 ppm PCBs. The transformers observed had non-PCB labels.



2.3.2 PCB Investigation Procedures

This section presents a summary of the procedures used in previous investigations for the sampling and analyses of PCBs. **Appendix A** presents a summary of PCB analytical data from previous investigations.

- **2003/Preliminary Site Investigations by WTI.** Soil and hydraulic oil samples were collected by WTI at potential PCB impact locations identified in the Phase I ESA Report (Hart Crowser, 2002). Results of this sampling indicated detection of PCBs at concentrations greater than 1 mg/kg in the following samples:
 - SS-4, a soil sample obtained from oil-impacted soil located beneath drain valves of transformers located immediately south of the former Rod Mills No.1 and No. 2.
 - Aroclor 1254: 1.4 mg/kg.
 - Aroclor 1260: 3 mg/kg.
 - SS-5, a soil sample collected from the same oil-impacted soil area as described for SS-4.
 - Aroclor 1254: 0.98 mg/kg.
 - Aroclor 1260: 2.2 mg/kg.
 - RM-1-3, an oily water sample collected in a sub-basement located near the middle/south side of Rod Mill No. 3.
 - Aroclor 1248: 7.4 mg/kg
 - Aroclor 1254: 18 mg/kg
 - Aroclor 1260: 6 mg/kg
- **2004/ESI by IEPA.** Soil and groundwater water samples collected by IEPA were analyzed for PCBs. Only one sample (X131, a sludge sample) was reported with total PCB concentrations above 1 mg/kg (1.4 mg/kg).
- **2006 to 2008/ CSIs by CEC for USS.** Multiple soil and groundwater samples were analyzed for PCBs.
- **2013/SSI by URS for USS.** Soil samples were collected to characterize PCBs detected at SG107 in the CSI. Groundwater samples were also collected for PCB analyses.



2.3.3 Locations with PCB Impacts

This section provides information with respect to locations with total PCB concentrations above 1 mg/kg as shown in **Figure 3**. **Appendix A** presents a summary of PCB analytical data from previous investigations.

2.3.3.1 Soil Sample Location

Central Parcel/Remediation Area 8

As shown in **Figure 3**, there are six locations near the front entrance (*i.e.*, SG006, SG106, SG107, SB207, SG109, and SG110) at the Central Parcel with total PCB concentrations greater than the TACO Tier 1 RO of 1 mg/kg.

- SG006 (0.083-0.167 feet bgs)/ Total PCB concentration: 4.05 mg/kg
 - Aroclor 1248: 2.2 mg/kg
 - Aroclor 1254: 1.5 mg/kg
 - Aroclor 1260: 0.35 mg/kg
- SG106 (2 feet bgs)/ Total PCB concentration: 4.05 mg/kg
 - Aroclor 1248: 3.4 mg/kg
 - Aroclor 1260: 0.65 mg/kg
- SG106 (2-3 feet bgs)/ Total PCB concentration: 3.17 mg/kg
 - Aroclor 1248: 2.6 mg/kg
 - Aroclor 1260: 0.57 mg/kg
- SG107 (0-0.5 feet bgs)/Total PCB concentration: 41.4 mg/kg
 - Aroclor 1248: 38 mg/kg
 - Aroclor 1260: 3.4J mg/kg ("J"-qualifier indicates reported value is estimated)
- SB207 (Advanced by URS during the SSI in 2013 to verify PCB concentrations reported in a surface sample at SG107, collected by CEC in 2008 as part of the CSI).
 - SB 207 (0-0.5 feet bgs)/Total PCB concentration: 585 mg/kg
 - Aroclor 1248: 450 mg/kg
 - Aroclor 1254: 100 mg/kg
 - Aroclor 1260: 35J mg/kg
 - SB207 (1.5-2.5 feet bgs)/Total PCB concentration: 2.4 mg/kg



- Aroclor 1248: 1.9 mg/kg
- Aroclor 1254: 0.4 mg/kg
- Aroclor 1260: 0.17J mg/kg
- SG109 (0-0.5 feet bgs)/Total PCB concentration: 2.46 mg/kg
 - Aroclor 1248: 2 mg/kg
 - Aroclor 1260: 0.46 mg/kg
- SG110 (0-0.5 feet bgs)/Total PCB concentration: 3.8 mg/kg
 - Aroclor 1248: 3.4 mg/kg
 - Aroclor 1260: 0.39 mg/kg

Central Parcel/Remediation Area 9

- SG004 (0.167-0.25 feet bgs)/Total PCB concentration of 2.81 mg/kg
 - Aroclor 1254: 0.51 mg/kg and
 - Aroclor 1260: 2.3 mg/kg
- SG102 (0-0.5 feet bgs) (Advanced by CEC in 2007, approximately 10 feet from SG004, to confirm the PCB data reported in the sample collected at SG004 in 2006)/Total PCB concentration of 1.7 mg/kg
 - Aroclor 1260: 1.7 mg/kg

During the SSI in 2013, a soil boring SB205 was advanced in the vicinity of SG004 and SG102 to delineate the extent of PCBs at these locations. Aroclor 1260 was detected at 0.07J mg/kg in the surface soil sample (0-0.5 feet bgs) collected at SB205 and PCBs were not detected in the subsurface soil sample (1.5-2.5 feet bgs) collected at this location. Therefore, the horizontal extent of PCBs previously reported at SG004 and SG102 is expected to be limited and the vertical extent has been delineated based on data collected at SB205.

2.3.3.2 Sludge Sample Location

Aroclor 1254 was detected at 1.4 mg/kg in Sample X131, collected by the IEPA in 2004, as part of the ESI, from sludge on the floor in the basement of the #3 Rod Mill building in the Central Parcel. When implementing remedial activities, this location (Remediation Area 10) will be inspected and housekeeping activities will be conducted. Debris on the floor will be removed and solids in the adjacent sump will be emptied. All of the debris and solids removed from this location will be placed in drums as described in **Section 2.6**. Samples of removed material will be collected for laboratory analyses and wipe sampling may be collected pending results of laboratory analyses. Information regarding the management, testing, and off-site



disposal of removed material is presented in **Section 2.6** and information regarding actions to be considered is presented in **Section 2.8**.

2.3.4 Remediation Action Implementation

This section presents remedial procedures designed based on the overall strategy of:

- Remediating the horizontal and vertical extent of PCB impacts by excavating soil impacted by PCB to meet the following ROs.
 - 1 mg/kg for impacted locations at Remediation Area 8.
 - 1 mg/kg for impacted locations at Remediation Area 9.
- Performing housekeeping activities at the previous sample location X131 (Remediation Area 10). Debris on the floor and solids from the adjacent sump will be placed in drums and samples will be collected and analyzed for PCBs, as described in **Section 2.6**. **Section 2.8** presents procedures to be considered if detected concentrations of PCBs in sludge samples exceed 10 mg/kg.

This section describes the activities and controls to excavate and backfill Remediation Areas 8 and 9. Remedial action implementation is divided into four discrete tasks: site preparation, site control, excavation/backfilling and material handling, and site restoration. These tasks are described in detail below.

2.3.4.1 Site Preparation

Site preparation is necessary at the Site for implementation of the selected remedial technology. Site preparation work will include, but is not limited to, the following:

- Mobilization of construction equipment and facilities.
- Installation of temporary construction facilities and controls.
- Installation of stormwater and erosion control measures.
- Construction of decontamination pads.
- Clearing underground utilities in and around the project area through a pre-work on-site joint utility meeting and a private locating service.



2.3.4.2 Site Control

Site control is an important element of the remedial action because of the proximity of the work to nearby residences and businesses. As such, site security and access, and control procedures for dust, odor, and stormwater will be enforced.

Security and Access

Temporary fencing may be installed, near the front entrance at Remediation Area 8, to supplement existing perimeter fencing in order to control access to the Site during remedial action implementation. The temporary fence will be large enough to ensure safe working conditions and be covered with fabric to reduce noise and dust or vapor emissions off-site. Also, warning signs will be posted on the fence during remedial action.

The gate at the 927 Collins Street front entrance will be designated for personnel and equipment access. This gate is always locked and access control is enforced by personnel with a contract security company that provides around the clock security. Only authorized personnel will be allowed to enter the Site. They will be allowed to remain on-site only as long as necessary to perform their duties. All authorized site workers and visitors will be required to sign in upon entry and sign out upon departure.

Control of Dust, Odor, and Stormwater

During site activities, control measures typically used at construction sites (e.g., sprinkling the ground surface with water) may be implemented to suppress dust. If necessary, the excavation will be covered with plastic sheeting during non-working hours to control odors. Dust control measures will also help to minimize and control odor during the remedial action activities. Barricades, such as orange traffic cones will be located outside of the excavation to warn personnel that a below grade opening is near.

A real-time air monitoring program will be implemented as part of the site health and safety plan (HASP) to monitor concentrations of PCBs in air samples. Results of this air monitoring program will be used to determine the necessity of engineering controls or personal protective equipment (PPE) for dust and odor for the protection of field workers.

In order to control stormwater run-off and erosion from work areas, various erosion and stormwater control measures may be installed at the perimeter of the work areas, if warranted. Water contained within active work zones and excavations will be pumped to appropriate tanks for handling and disposal as investigation-derived waste (IDW). Remediation contractor will be required to employ techniques within the work zones to enhance erosion control, sedimentation, and control stormwater flow. On-site stormwater drains will be managed to avoid runoff from remedial activities.



2.3.4.3 Excavating, Backfilling, and Material Handling

Landfill Acceptance

Material excavated during implementation of the remedial action will be disposed at pre-approved landfills. Excavated soils could potentially be transported to alternate, approved landfills based on the space availability and characterization of the wastes.

- Excavated material with total PCB concentrations greater than 50 mg/kg will be disposed of at a TSCA-approved landfill.
- Excavated material with total PCB concentrations less than 50 mg/kg will be disposed of at a permitted, licensed, or registered non-TSCA landfill, pending results of waste characterization described in **Section 2.6**.

Dewatering

Table 1 presents a summary of information regarding depth of previous PCB sampling, distance to groundwater, and estimated extent of excavation at each PCB-impacted location. Dewatering of the excavation may be necessary at locations where impacted material is encountered at or close to the groundwater table. Remedial contractors will propose, based on field conditions, if dewatering measures will be used to lower the water table to an appropriate depth for excavation of source material to occur and for placement of clean fill.

Water that accumulates in excavations (from groundwater seepage or stormwater after rain events) will be removed by creating a low area (sump) within the excavation and using a pump to discharge water from low area to tanks.

The dewatering system will be installed in such a way as to minimize obstructions for excavation activities. The removed water will be treated as IDW and be handled and disposed of appropriately.

Slope, Benching, and/or Shoring

Based on the shallow depth of excavation and the relatively open areas surrounding locations with source materials, shoring is not expected to be required to maintain slope stability.

Excavation

Prior to initiating excavation activities, underground utilities will be located in and around the work area utilizing the Joint Underground Locating Information for Excavators (JULIE). Encountered utilities will be supported, rerouted, capped, or worked around in a manner which will allow for continued service.

A truck-mounted backhoe or equivalent equipment will be used to excavate impacted soil. In locations where utilities are encountered, alternative excavation equipment (hand digging or air knife) may be utilized.



- **Table 1** presents a summary of information regarding depth of previous PCB sampling, distance to groundwater, and estimated extent of excavation at each PCB-impacted location.
 - Remediation Area 8 will consist of two excavation areas:
 - Remediation Area 8A -- An area, approximately 16 feet long by 16 feet wide by 3 feet deep, centered on the location of SB207 (*i.e.*, the location with the highest PCB concentrations) and includes SG006 and SG107.
 - Remediation Area 8B -- An area, approximately 55 feet long by 15 feet wide by 3 feet deep, with the north-south grid axes and the east-west axes centered on the location of SG106. Locations SG 109 and SG110 are also covered by Remediation Area 8B.
 - Remediation Area 9 will consist of an area, approximately 9 feet long by 9 feet wide by 2 feet deep, centered on the locations of SG004 and SG102 where PCB concentrations exceeded 1 mg/kg.

Locations of the excavations areas are provided on **Figure 4**.

Stockpiling

Excavated soil will be stockpiled for characterization sampling prior to transportation offsite. Stockpiles will be covered with polyethylene sheeting to avoid migration of PCBs via run-off after rain events or emission of airborne particulates.

Transportation and Disposal

Waste transport and disposal will be handled by licensed waste handler. Trucks transporting material off-site will be lined and covered, as necessary, for highway travel to the selected landfill. The appropriate paperwork (*e.g.*, manifests) for hauling and disposal will accompany each load. Disposal certifications will be provided by the disposal contractor following acceptance of the waste.

Decontamination

All sampling equipment will be decontaminated according to the procedures detailed in Section 4.4 of the Site quality assurance project plan (QAPP) and Standard Operating Procedure (SOP) F501 (**Appendix C**). All sampling equipment that makes contact with impacted soil will be decontaminated before use at another sampling location. All non-dedicated sampling equipment, such as sample knives, will also be decontaminated before reuse at another location.

Equipment that comes into contact with potentially impacted material will be decontaminated prior to leaving the Site. This includes all equipment entering the Site. All on-road vehicles leaving the Site will be inspected and decontaminated as necessary to prevent the spread of



impacted materials off-site. A heavy equipment decontamination area will be constructed to collect decontamination water for disposal off-site.

2.3.4.4 Removal of PCB sludge

If sludge material is present at X131, it will be removed to drums following appropriate protocols for waste handling, storage, testing, and off-site disposal. The area with sludge will be double washed and rinsed in accordance with procedures in *Wipe Sampling and Double Wash/Rinse Cleanup as Recommended by the Environmental Protection Agency PCB Spill Cleanup Policy* (USEPA, 1991). Wipe sampling will be conducted following the washing/rinsing procedures, as discussed in Section 2.4.2.

2.3.4.5 Site Restoration

Upon completion of the remedial action activities, the Site will be restored to the current surface conditions. Temporary fencing, filter fabrics, decontamination pad, trailer, portable toilet, and field equipment will be removed from the Site. Excavated material (e.g., concrete or asphalt pavement) will be collected and disposed of off-site as IDW.

2.4 Verification Sampling

This section presents the plan developed to verify ROs are met post-excavation. Figure 4 shows remediation locations.

For clarity, ROs for PCB areas are tabulated below.

Subarea	Sample Location ID	Remedial Action Location ID	RO
PCB in Soil			
Central Parcel	SB207/SG006/SG107	Remediation Area 8A	≤1 mg/kg
	SG106/ SG109/SG110	Remediation Area 8B	≤1 mg/kg
	SG004/SG102	Remediation Area 9	≤1 mg/kg
PCB in Sludge			
Central Parcel	X131	Remediation Area 10	To be determined. See Section 2.6 and Section 2.8 for additional information.

2.4.1 Procedures for Verification Sample Collection

Excavation verification samples will be collected as grab samples from the bottom of the excavation using stainless-steel trowel and/or spoons, provided that the excavation is safe to enter and would not violate applicable Occupation Safety and Health Administration (OSHA) regulations. Should the excavation be unsafe to enter (e.g., when the excavation is greater than 4 feet), samples will be collected using a decontaminated backhoe bucket. Soil from the bucket will be taken using a stainless-steel trowel and/or spoon and then transferred to sample containers for analysis.



2.4.1.1 Post-Remediation Verification Sampling at Remediation Area 8

Table 1 shows estimated areal extents and volume for Remediation Area 8. It should be noted that areal extents and excavation depth shown are estimated for planning purposes. The actual extent of excavation will be determined in the field.

As indicated in Section 2.3.3.1, although total PCB concentrations at SG006, SG106, SG107, SG109, and SG110 were below the criterion for PCBs to be considered as source material (*i.e.*, 50 mg/kg); these locations will be remediated along with SB207 at Remediation Area 8 due to their proximity to SB207 (see Figure 3).

Presented below is a summary of the procedures that will be used to collect verification samples at Remediation Area 8. This sampling plan has been designed to meet requirements in Subpart O of 40 CFR 761 (*i.e.*, 40 CFR 761.280 through 40 CFR 761.298), as specified in 40 CFR 761.61 (a)(6) for bulk PCB remediation waste:

- Minimum Number of Samples

- According to 40 CFR 761.283 (a), a minimum of three samples are required for each type of bulk PCB remediation waste at each PCB cleanup waste location.
- At Remediation Area 8, there are two cleanup areas (*i.e.*, unpaved surface by the front entrance to the Site, subdivided into Remediation Areas 8A and 8B) and one type of remediation waste (*i.e.*, soil). Therefore, a minimum of six soil samples (*i.e.*, a minimum of three samples each from Remediation Areas 8A and Area 8B) are required.

- Selection of Sample Locations

To reduce the total number of samples to be collected for laboratory analyses, composite samples will be collected using procedure as provided in 40 CFR 761.289(b)..

- **Remediation Area 8A** – Presented below are the procedures that will be used to select three sample locations at Remediation Area 8A, as shown in Appendix B-1, Figure 1.

1. Mark out an area approximately 16 feet long by 16 feet wide, centered on the location of SB207 and includes SG 006 and SG107.
2. Overlay the area with a 1 meter (approximately 3.3 feet) square sampling grid, based on communication with Jennifer Dodd of USEPA on February 26, 2015.
3. A single sample will be collected from the initial compositing area for laboratory analyses by compositing samples from each of the nine grid



points, in equal volume increments, by a geologist overseeing the excavation.

4. Subsequent compositing areas form concentric square zones, one grid interval wide, around the initial compositing area and around each successive subsequent compositing area. Two composite samples will be collected from subsequent compositing areas for laboratory analyses by compositing samples from eight grid points.
- **Remediation Area 8B** -- Presented below are the procedures that will be used to select sample locations at Remediation Area 8B, as shown in **Appendix B-1, Figure 2**.
 1. Mark out an area approximately 55 feet long by 15 feet wide, centered on the location of SG106 and includes SG 109 and SG110 to its west and east, respectively.
 2. Overlay the area with a 1.5 meter (approximately 5 feet) square sampling grid.
 3. An area of inference, as described in 40 CFR 761.283(d) for a composite sample is determined by summing the individual areas of inference for each of the individual samples combined in the composite. As shown in **Appendix B-1, Figure 2**, the estimated 54 feet by 15 feet excavated area can be subdivided into eight inference areas. A composite sample, consisting of equal volume increments from each of the grid points, will be collected from each area of inference..

The verification soil samples from Remediation Area 8 will be analyzed for PCBs. Quality control (QC) procedures including duplicate samples and laboratory analytical methods are discussed in **Section 2.5.4**.

2.4.1.2 Post-Remediation Verification Sampling at Remediation Area 9

Table 1 shows estimated areal extents and volume for Remediation Area 9. It should be noted that areal extents and excavation depth shown are estimated for planning purposes. The actual extent of excavation will be determined in the field.

SG004 and SG102 (Because SG102 is in proximity to SG004 [*i.e.*, approximately 10 feet northwest of SG004] are locations with total PCB concentrations greater than the RO of ≤ 1 mg/kg (**Figure 3**). These two locations will be handled as one excavated area [*i.e.*, Remediation Area 9]).

Presented below are the procedures that will be used to select sample locations at Remediation Area 9, as shown in **Appendix B-1, Figure 3**.



- Minimum Number of Samples
 - According to 40 CFR 761.283 (a), a minimum of three samples are required for each type of bulk PCB remediation waste at each PCB cleanup waste location.
 - At Remediation Area 9, there is one cleanup areas and one type of remediation waste (*i.e.*, soil). Therefore, a minimum of three soil samples are required.
- Selection of Sample Locations
 1. Mark out an area approximately 9 feet long by 9 feet wide, centered on the location of SG004 and SG102.
 2. Overlay the area with a 0.5 meter (approximately 1.6 feet) square sampling grid.
 3. A single sample will be collected from the initial compositing area for laboratory analyses by compositing samples from each of the nine grid points, in equal volume increments, by a geologist overseeing the excavation.
 4. Subsequent compositing areas form concentric square zones, one grid interval wide, around the initial compositing area and around each successive subsequent compositing area. Two composite samples will be collected from subsequent compositing areas for laboratory analyses by compositing samples from eight grid points.

Verification soil samples will be collected and analyzed for PCBs. QC procedures including duplicate samples and laboratory analytical methods are discussed in **Section 2.5.4**.

2.4.2 Verification Sampling at Remediation Area 10

No excavation will be conducted at Remediation Area 10. Information regarding the management, testing, and off-site disposal of material to be removed from this area is presented in **Section 2.6** and information regarding actions to be considered is presented in **Section 2.8**.

2.5 Procedures for Field Quality Assurance/Quality Control

Verification soil samples will be collected and handled to assure that data quality standards are met and samples collected during the field activities represent the actual field conditions. General protocols for sampling, sample handling, storage, chain-of-custody, laboratory, and field analysis are described in the QAPP, presented as Appendix B to the approved RAP (USS, 2014). Applicable SOPs are included as **Appendix C** to this work plan. This section discusses the following quality assurance/quality control (QA/QC) requirements:

- Field documentation



- Decontamination
- Calibration procedures and frequency
- QC samples and collection procedures
- Sample handling procedures

2.5.1 Field Documentation

Information pertinent to the field investigation will be recorded in a bound field logbook. The front of the field logbook will be labeled with the following information:

- Person or organization to whom the book is assigned
- Book number
- Project name and number
- Start date
- End date

Data will be recorded in the field logbook in a legible manner. Logbook entries will contain accurate and detailed documentation of daily project activities. Entries in the logbook will include the following, as applicable:

- Site identification
- Site personnel
- Volume of material excavated
- Number of trucks hauling material off-site
- Observation of decontamination Location and description of sampling points
- References to photographs of the field activities
- Sample identification number
- Number of samples collected
- Date and time of sample collection
- Reference to sample location map
- Collector's name
- Field observation
- Number of QA/QC samples collected



- Sample distribution (e.g., QA laboratory, agency split)
- Field measurements made (e.g., PID/FID readings)
- End of the day site walkthrough to check and ensure excavation is secure and safe

The field logbook will be maintained while investigation related field activities are in progress. Photographs may be taken to provide visual evidence of significant items or anomalies. The photographs will be referenced appropriately in the field notebook. Following the fieldwork, the field logbook will become part of the project file.

2.5.2 Decontamination

Prior to initiating soil sampling activities, a decontamination area will be established on-site. The sampling equipment will be decontaminated before sampling and between sampling events to prevent potential cross-contamination. Sampling equipment will be decontaminated between each sampling event using an Alconox (or similar detergent) wash, potable water rinse, and distilled water rinse. Additional decontamination procedures may be required (i.e., methanol or isopropanol rinse) in the event that tarry or oily materials come into contact with the sampling equipment.

2.5.3 Procedures for Calibration

Field-testing equipment to be used for analytical determinations at the Site fall into two categories: those calibrated by the manufacturers and those calibrated on a scheduled, periodic basis. Measuring and testing equipment will be calibrated at prescribed intervals and/or prior to use. Field-sampling instrumentation that requires calibration will be calibrated at the beginning of each day and when conditions indicate that more frequent calibration is required.

Equipment will be calibrated using reference standards or accepted values of natural physical constants. If national standards do not exist, the basis for calibration will be documented. Field equipment calibration will be performed as described in the manufacturer's literature for each instrument. Equipment that fails calibration or becomes inoperable during use will be removed from service and either segregated to prevent inadvertent use or tagged to indicate it is out of calibration.

2.5.4 Procedures for QC Sample Collection

QC samples, which include trip blanks, field or rinsate blanks, duplicates, and matrix spikes will be collected to assess the quality of the data resulting from the field sampling and analytical program. The following describes the collection procedures, rationale, and frequency for each QC sample type.



2.5.4.1 Equipment/Rinsate Blanks

Equipment/rinsate blanks will be collected to determine the probability of sample contamination or cross-contamination from reusable equipment subsequent to their decontamination. Equipment blanks are analyte-free reagent water samples that contact sampling equipment under field conditions and are analyzed to detect any contamination from sampling equipment, cross-contamination from previously collected samples, or contamination from conditions during sampling (i.e., airborne contaminants that are not from the waste being sampled). The minimum number of required equipment/rinsate blanks when reusable sampling equipment is used is one per every 20 investigative samples, or, if there are fewer than 20 samples per matrix, one per matrix.

2.5.4.2 Field Blanks

Field blanks will be collected to check for procedural contamination when equipment/rinsate blanks are not collected due to use of disposable sampling equipment. Field blanks are analyte-free reagent water transported to the site and transferred into appropriate sample containers on-site. The minimum number of required field blanks is one per every 20 investigative samples; or, if there are fewer than 20 samples per matrix, one per matrix.

2.5.4.3 Field Duplicates

Field duplicates will be collected to document precision. The precision resulting from field duplicates is a function of the variance of the matrix being sampled, the variance of the sampling technique, and the variance of the analytical technique. The minimum number of required field duplicates is one per every 20 investigative samples; or, if there are fewer than 20 samples per matrix, one per matrix.

2.5.4.4 Matrix Spike/Matrix Spike Duplicate

Matrix Spike/Matrix Spike Duplicate (MS/MSD) will be collected to document the bias and precision of a method. The precision of the method is a variance of the analytical techniques. The minimum number of required MS/MSD samples is one per every 20 investigative samples; or, if there are fewer than 20 samples per matrix, one per matrix.

2.5.5 Procedures for Sample Handling

A brief summary of field sample handling procedures, including numbering, chain-of-custody, shipping, and laboratories, is presented below.

2.5.5.1 Sample Numbering

Immediately upon collection, each sample bottle will be labeled with an adhesive label and affixed with a sample tag.

Numbering of Verification Soil Samples

Each soil sample will be given a unique identifier.



- The first field of the sample name will consist of "SI," designating samples collected from PCB-impacted areas at the Site as part of the self-implemented remediation activities.
- The first part of the second field will be the sample source code. This will be "RA8A" and "RA8B" for soil verification samples to be collected at Remediation Areas 8 and "RA9" for samples collected at Remediation Area 9. The second part of the second field is a double-digit code to denote samples collected from each compositing area.
- The third field will be the sample matrix code. Surface soil samples, defined as oil samples collected from 0-0.5 feet bgs, will be designated as "SS" and subsurface soil samples (defined as soil samples collected below 0.5 feet bgs) will be designated as "SB".
- The first part of the fourth field of the sample name will be the sample collection date code, which will be an eight-digit number. For example, a sample collected on April 2, 2015 would have the code 04022015. The second part of the fourth field will be the code for QC samples, if collected.
 - When a field duplicate is being taken, an "FD" will follow the date code.
 - When a matrix spike (MS) or matrix spike duplicate (MSD) sample is being taken, the sample date will be followed by "MS" or "MSD."
 - When an equipment blank (rinsate) is being taken, an "EBK" will follow the date code.
 - When a field blank is being taken, an "FBK" will follow the date code.

2.5.5.2 Chain-of-Custody

Chain-of-custody records will be completed and enclosed in the shipping coolers with the appropriate samples. These will designate the transfer of custody and method of shipment.

2.5.5.3 Sample Shipment

Samples will be packed so as to protect from breakage and shipped in coolers. Each cooler will be sealed with chain-of-custody tape so that any opening of the cooler during shipment will be indicated. Ice will be used to maintain a temperature of 4 degrees centigrade (°C). The samples will be sent by an overnight carrier or by hand courier to insure delivery to the laboratory within 24 hours after collection.

2.5.5.4 Laboratories

Soil and wipe samples that have been selected for laboratory analysis will be shipped to a National Environmental Laboratory Accreditation Conference (NELAC)-accredited laboratory. Samples will be extracted and analyzed in accordance with the following methods, as required in 40 CFR 761.292:



- Samples will be extracted using SW-846 Method 3500B/3540C or Method 3500B/3550B (USEPA, 1997); and
- Analyzed for PCB Aroclors using SW-846 Method 8082.

2.6 Procedures for Managing Investigation-Derived Wastes

Excavated soil will be stockpiled by Remediation Areas for testing prior to off-site disposal. All excess sample material, or fluids (including decontamination water), disposable PPE, and other IDW that are potentially contaminated with chemicals, will be placed into drums, tanks or other suitable containers for subsequent disposal. Management of IDW is described in SOP F504 in **Appendix C**.

The disposal of the excavated material and fluids will be in accordance with applicable laws and regulations. The method of disposal will be determined after the analytical program is complete and the nature of the IDW can be determined.

Presented below is a summary of the procedures that will be used for sampling IDW for off-site disposal:

- **Excavated Soil**
 - Excavated soil from Remediation Areas 8 and 9 will be piled, separately, into a conical shape.
 - Eight soil samples will be collected from both piles following the procedure in 40 CFR 761.347(c). **Appendix B-2** presents diagrams to illustrate the methodology that will be used to select samples from a pile.
- **Used Sample Material and PPE**
 - Used sample material (e.g., wipes, absorbent pads) and PPE will be placed in drums and disposed off-site along with excavated soil.
- **Liquid Waste Generated**
 - Liquid waste generated will include water from the decontamination of equipment, water from washing and rinsing Remediation Area 10 prior to wipe sample collection, and water-in-fill removed during dewatering activities, if necessary.
 - Liquid waste will be containerized, logged, tested, and shipped to an off-site hazardous or non-hazardous landfill pending results of waste characterization in accordance with 40 CFR 260 through 268.



- Removed Material from Remediation Area 10
 - Material removed from Remediation Area 10 (i.e., debris on the floor and solids from adjacent sump) will be containerized and samples will be collected for laboratory analyses of total PCBs. In addition, containerized material will be logged, tested, and disposed of at an off-site hazardous or non-hazardous landfill pending results of waste characterization in accordance with 40 CFR 260 through 268.

2.7 Procedures for Internal QC Checks, Audits, and Corrective Action

Internal audits of field activities will be conducted at least once at the beginning of the verification sample collection activities. The audits will be conducted by the QA Officer.

2.8 Contingency Plan

2.8.1 Remediation Areas 8 and 9

The analytical data reported in verification soil samples (**Section 2.4.1**) will be reviewed to determine if PCBs are still present above ROs.

For Remediation Areas 8 and 9, USS may elect to either:

1. Continue vertical excavation in initial composite of subsequent areas that exceeded the RO and repeat cleanup verification sampling according to Subpart O; or,
2. Place a cap over the excavated areas where remediation waste with PCB concentrations > 1ppm and ≤ 10 ppm remain in place.

2.8.1.1 Continued Excavation

PCB analysis for the initial and subsequent composites will be evaluated to determine achievement of the ROs. Where exceedances of the ROs are still present, USS will continue excavation using the protocols in Subpart O. If the subsequent excavation is not conducive to the 1.5 meter grid interval in 40 CFR 761.283(b), USS will follow 40 CFR 761.283(c) for small cleanup sites.

2.8.1.2 Cap Requirements

The cap will meet the following requirements:

- The cap will have a minimum thickness of 10 inches of compacted soil or 6 inches of concrete or asphalt, as defined in 40 CFR 761.61(a)(7), and will be designed and constructed as specified in 40 CFR 264.310(a).
- Deed restriction for maintaining the cap, as specified in 40 CFR 761.61(a)(8).



2.8.2 Remediation Area 10

If results of removed material sampling (Section 2.6) indicate total PCB concentrations exceeding 10 mg/kg, USS will complete the following:

1. Perform double wash/rinse procedures of the surface as provided in *Wipe Sampling and Double Wash/Rinse Cleanup as Recommended by the Environmental Protection Agency PCB Spill Cleanup Policy* (USEPA, 1991),.
2. Conduct wipe sampling in accordance with procedures outlined in USEPA, 1991.

The need for further action will be evaluated, if wipe test results exceed 10 micrograms per 100 centimeter square ($10 \mu\text{g}/100 \text{ cm}^2$), a cleanup level established in USEPA, 1991 for high- and low-concentration spills at indoor commercial areas,

Each wipe sample, if collected, will be identified using the following identifier:

- The first field of the sample name will consist of "SI," designating samples collected from PCB-impacted areas at the Site as part of the self-implemented remediation activities.
- The second field will be the sample source code. This will be "RA10" for wipe samples to be collected at Remediation Area 10. The second part of the second field is a double-digit code randomly assigned in the field (and recorded in field notes) for wipe samples and QC samples. It should be noted that QC samples will not be explicitly identified in sample designation when submitting samples for laboratory analyses, based on guidance provided in *Wipe Sampling and Double Wash/Rinse Cleanup as Recommended by the Environmental Protection Agency PCB Spill Cleanup Policy* (USEPA, 1991).
- The third field will be the sample matrix code. Wipe samples will be designated as "WP".
- The fourth field of the sample name will be the sample collection date code, which will be an eight-digit number. For example, a sample collected on April 2, 2015 would have the code 04022015. The second part of the fourth field will be the left blank because QC samples will not be identified when submitting samples to the analytical laboratory.



3.0 HEALTH AND SAFETY

A project-specific HASP will be prepared to address planned remedial and soil sampling activities to be conducted at the Site. This HASP will be provided to all site workers for review. The function of the HASP is to inform personnel of the existing hazards and present methods to perform the work in a manner that will prevent the occurrence of an accident or exposure. Another function of the HASP is to provide policies and procedures to follow in the event of an accident, and to minimize exposures and/or injuries to site personnel.

All personnel who will be working in the exclusion zone and/or contaminant reduction zone will be required to read and understand the contents of the HASP, and sign an agreement to comply with the protocols and procedures stated in the HASP. Site safety issues will be addressed in an on-site kickoff meeting as well as daily pre-work meetings.



4.0 REPORTING AND RECORDKEEPING REQUIREMENTS

This section describes recording and recordkeeping that will be conducted to meet applicable requirements by the IEPA and USEPA.

4.1 IEPA's Requirement

Within 90 days after the completion of the remedial phase, a *Remedial Action Completion Report* will be submitted for review. Presented below is a preliminary outline of the report, prepared to provide information specified in 35 IAC 740.455. It should be noted that this outline may be modified to incorporate recordkeeping requirements specified by USEPA, as provided in 40 CFR 761.125(c)(5) (see **Section 4.2**).

Executive Summary

1.0 Introduction

1.1 Background

1.2 Objectives

2.0 Field Activities

2.1 Filed Activities Conducted

2.2 Remedial Activities Implemented and Performance of Remedial Technology

2.3 Measure taken to Ensure Compliance

3.0 Special Considerations

3.1 Engineer Barriers

3.2 Institutional Controls

3.3 Post-Remedial Monitoring

3.4 Other Conditions

4.0 Results

5.0 Conclusion

Appendices

Appendix A References

Appendix B Data Sources

Appendix C Environmental Notice Form

Appendix D Field Logs



Appendix E Laboratory Analytical Report

E-1 Laboratory Analytical Report

E-2 Accreditation Status of the Analytical Laboratory

E-3 Certification by an Authorized Agent of the Laboratory

Appendix F Licensed Professional Engineer Affirmation

4.2 USEPA's Requirement

4.2.1 Recording

USS will complete the following activities, within 60 days of completion of remedial activities, to meet requirements as outlined in 40 CFR 761.61(a)(8)(i).

- **40 CFR 761.61(a)(8)(i)(A)**

Record a notation to the deed to the property that will in perpetuity notify any potential buyer of the property:

- The land has been used for PCB remediation waste disposal and is restricted to use as a low occupancy area, as defined in 40 CFR 761.3.
- Of the existence of the fence or cap, if relevant, and the requirement to maintain the fence or cap.
- The applicable cleanup levels left at the Site, inside the fence, and under the cap.

- **40 CFR 761.61(a)(8)(i)(B)**

Submit a signed certificate to the USEPA Administrator indicate a notation as required under 40 CFR 761.61(a)(8)(i)(A) has been recorded.

As provided in 40 CFR 761.61(a)(8)(ii), USS may remove a fence or cap after conducting additional cleanup activities and attaining ROs that do not require a fence or cap.

4.2.2 Recordkeeping

USS will document information relevant to the cleanup activities as outlined in 40 CFR 761.125(c)(5) and incorporate information, as appropriate, into the *Remedial Action Completion Report* (Section 4.1).



5.0 SCHEDULE OF IMPLEMENTATION

USS will implement remedial activities within 30 days of the receipt of approval of this work plan.

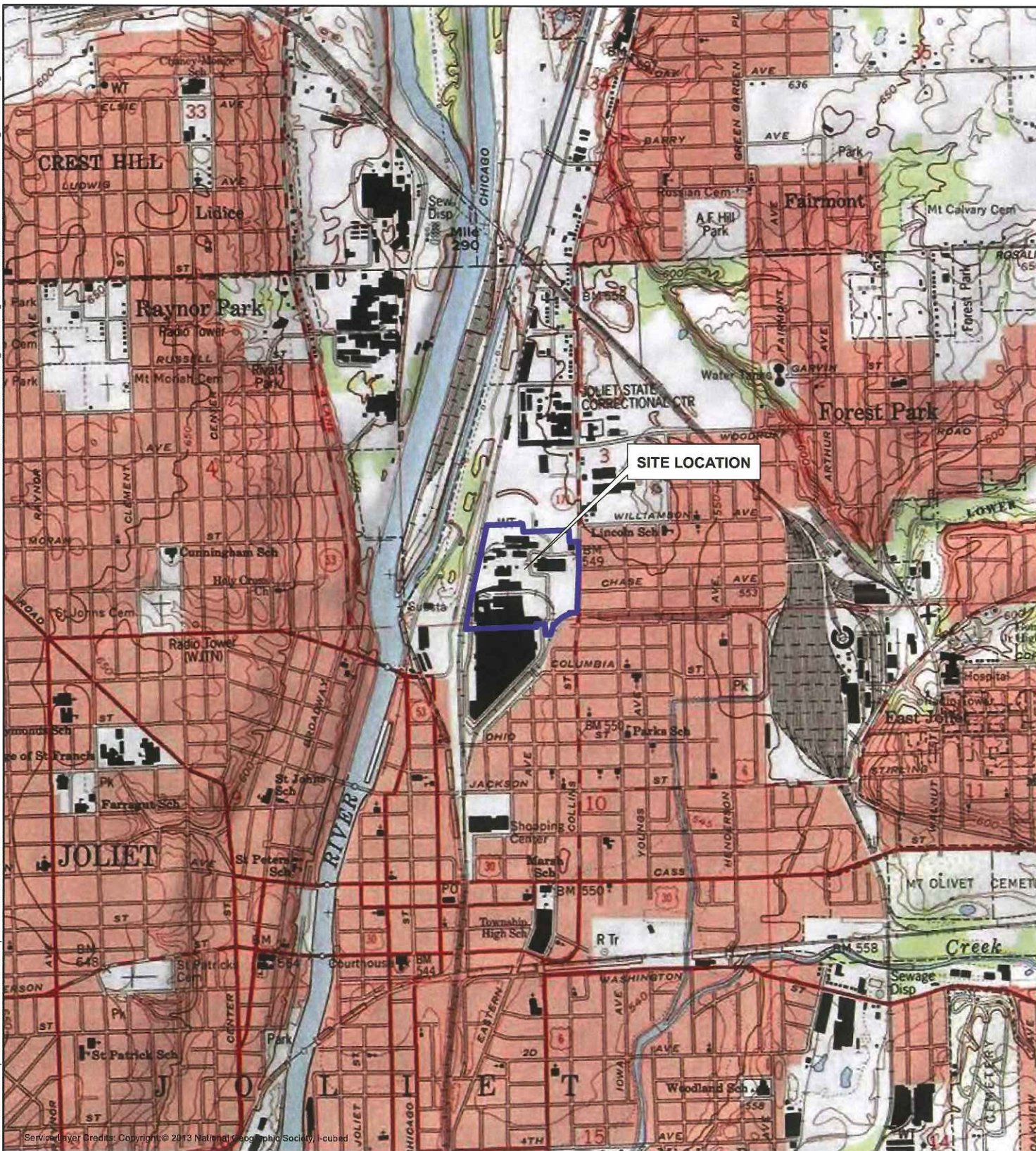
The remedial activities are estimated to take approximately three months working during normal business hours. This includes site preparation, excavation, backfilling, disposal, and site restoration. Work schedule may be adjusted based on field activities, weather conditions, and disposal facility business schedules.



6.0 REFERENCES

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Figures

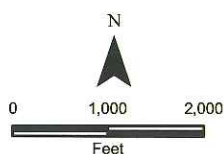


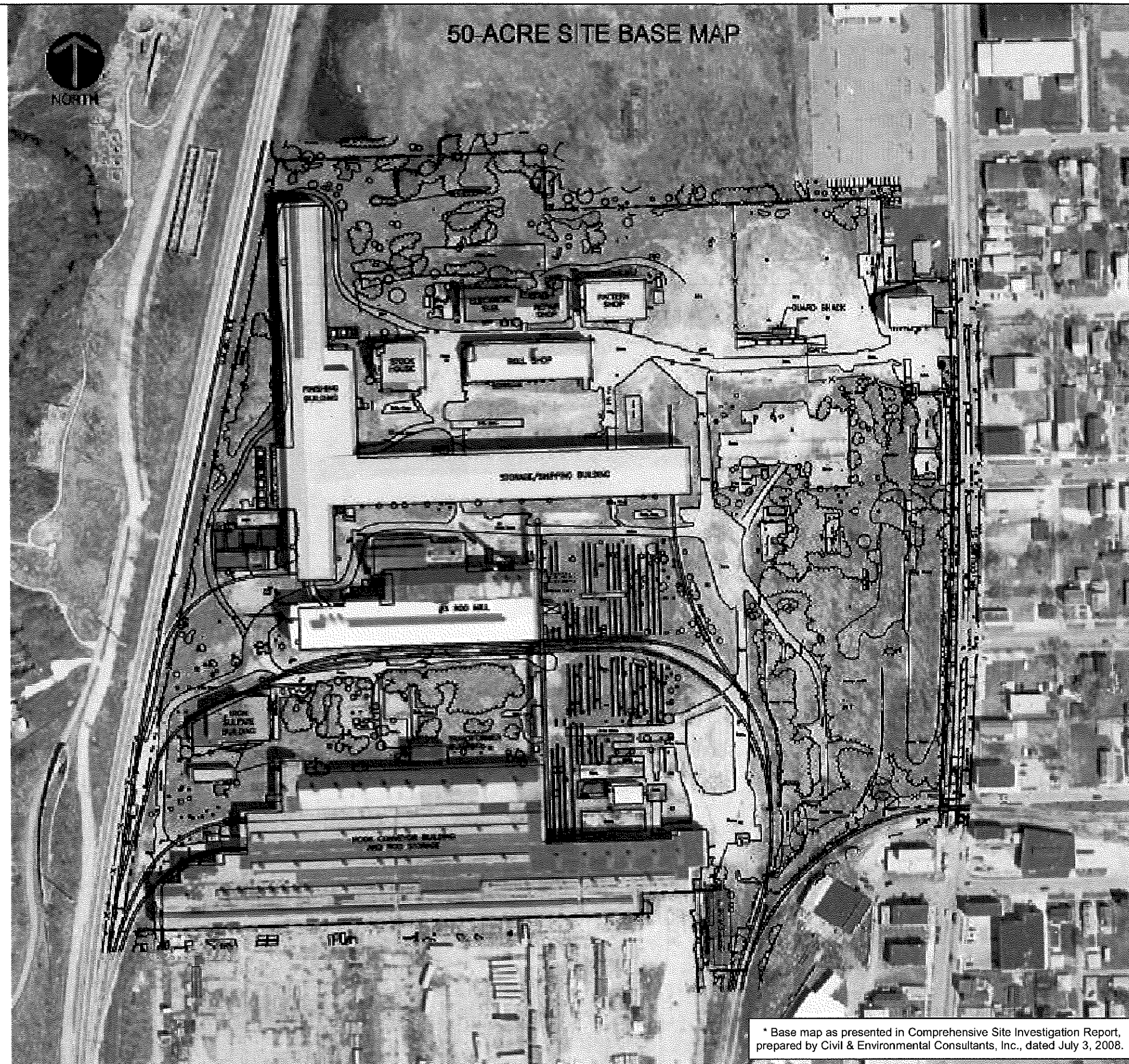
SITE LOCATION





FIGURE 1

FORMER BIRMINGHAM STEEL CORPORATION
 FACILITY - 50-ACRE PARCEL
 927 COLLINS STREET, JOLIET, ILLINOIS

AECOM





 SITE BOUNDARY
 CURRENT SITE FEATURE
 FENCE
 RETAINING WALL
 BUILDING

THE HORIZONTAL DATUM IS BASED ON THE NORTH AMERICAN DATUM OF 1983 (NAD 83) CONVERTED TO THE ILLINOIS STATE PLANE COORDINATE SYSTEM OF 1983 (SPC 83). ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88). BOTH HORIZONTAL AND VERTICAL DATUMS ARE IN U.S. SURVEY FEET. THE VERTICAL DATUM IS REFERENCED AS FEET ABOVE MEAN SEA LEVEL (MSL) IN THE TEXT SECTIONS OF THE APPLICATION.

FIGURE 2

FORMER BIRMINGHAM STEEL CORPORATION
FACILITY - 50-ACRE PARCEL
927 COLLINS STREET, LOJIST, ILLINOIS

AECOM

Table

Table 1
Summary of PCB Remediation Areas

Birmingham Steel Joliet Works 50-Acre Facility, Joliet, Illinois

Location										Estimated Volume			
Subarea	Sample Location ID	Sample Matrix	Remedial Action Location ID	Remediation Objective		Concentration of total PCBs	Sample Depth	Water Table		Areal Extents	Excavation Depth	Volume	
						(mg/kg)	(Feet bgs)	(Feet bgs)		(Feet²)	(Feet)	(Feet³)	(yd³)
Central Parcel	SB207	Soil	Remediation Area 8A	1 mg/kg		585	0 to 0.5	6		16 x 16 <i>256 -</i>	3	768	28
					2.4	1.5-2.5							
	SG006	Soil				4.05	0.083-0.167	NA					
	SG107	Soil				41.4	0-0.5	NA					
	SG 106	Soil	Remediation Area 8B	1 mg/kg		4.05	2-2	NA		55 x 15 <i>825</i>	3	2,475	92
					3.17	2-3	NA						
	SG109	Soil				2.46	0-0.5	NA					
	SG110	Soil				3.8	0-0.5	NA					
	SG004	Soil	Remediation Area 9	1 mg/kg		2.81	0.167-0.25	3	(a)	9 x 9	2	162	6
	SG102	Soil				1.7	0-0.5						
	X131	Sludge on Concrete Floor	Remediation Area 10	(b)		1.4	NA	NA		NA	NA	NA	NA
Total (Estimated)													126

0.006 acre
0.019 acre
= 0.025 acre

bgs: Below Ground Surface.
mg/kg: Milligram per kilogram.
NA: Not Applicable.
PCB: Polychlorinated Biphenyls.
yd³: Cubic Yards.

(a) Based on water level at a nearby location (SB205).

(b) Housekeeping activities will be conducted at Remediation Area 10. Material to be removed from this area (e.g., debris on the floor and solids in adjacent sump) will be containerized for off-site disposal. A sample of the removed material will be sent to the laboratory for PCB analysis. USS may perform double wash/rinse procedure and subsequent wipe sampling, if concentration of total PCB in the sample of removed material exceeds 10 mg/kg.

Appendix A

Summary of PCB Data from Previous Investigations

Appendix A-1	Data Collected by WTI (2003)/Soil and Oily Water Samples
Appendix A-2	Data Collected by IEPA (2004)/Soil and Sludge Samples
Appendix A-3	Data Collected by CEC (2006 and 2007) Soil and Groundwater Samples
Appendix A-4	Data Collected by URS (2008 and 2009) Groundwater Samples
Appendix A-5	Data Collected by URS (2013) Soil and Groundwater Samples

Appendix A-1

**TABLE A-1
PCB ANALYTICAL RESULTS**

Analyte	Unit	PRG for Industrial Soil	PRG for Residential Soil	Analytical Method	Sample ID	MF-1		RM-1 ³		RM-1-2	
					Collected Date:	10/13/03		10/2/03		10/13/03	
					Lab Sample ID	0310-1333		0310-0672		0310-1332	
Polychlorinated Biphenyls (PCB)											
Aroclor-1248	mg/kg	0.74	0.22	8082	12672-29-6	1	UD				
Aroclor-1254	mg/kg	0.74	0.22	8082	11097-69-1	1	UD				
Aroclor-1260	mg/kg	0.74	0.22	8082	11096-82-5	1	UD				
PCB Total-TCL	ma/ka	0.74	0.22		1336-36-3	1	UD				

D: Sample was diluted prior to analyses.

J: Concentration was estimated.

PRG: Preliminary Remediation Goal

U; Analyte not detected.

¹ USEPA Region 9 Industrial Soil Preliminary Remediation Goals.

² USEPA Region 9 Residential Soil Preliminary Remediation Goals.

³ Not Analyzed - Broken by the Laboratory

Appendix A-1

**TABLE A-1
PCB ANALYTICAL RESULTS**

Analyte	Unit	PRG for Industrial Soil	PRG for Residential Soil	Analytical Method	RM-1-3		RM-2		SS-3		SS-4		SS-5	
					10/17/03		10/2/03		10/2/03		9/30/03		9/30/03	
					0310-1717		0310-0673		0310-0669		0310-0465		0310-0466	
		1	2											
Polychlorinated Biphenyls (PCB)														
Aroclor-1248	mg/kg	0.74	0.22	8082	7.4	D	1	UD			1	UD	1	UD
Aroclor-1254	mg/kg	0.74	0.22	8082	18	D	1	UD			1.4	D	0.98	JD
Aroclor-1260	mg/kg	0.74	0.22	8082	6	D	1	UD			3	D	2.2	D
PCB Total-TCL	mg/kg	0.74	0.22		32	D	1	UD			4.3	D	3.2	D

D: Sample was diluted prior to analyses.

J: Concentration was estimated.

PRG: Preliminary Remediation Goal

U; Analyte not detected.

¹ USEPA Region 9 Industrial Soil Preliminary Remediation Goals.

² USEPA Region 9 Residential Soil Preliminary Remediation Goals.

³ Not Analyzed - Broken by the Laboratory

Appendix A-1

**TABLE A-1
PCB ANALYTICAL RESULTS**

Analyte	Unit	PRG for Industrial Soil	PRG for Residential Soil	Analytical Method	TP-7-4		TP-8-7		TP-8-OIL		TP-9-6	
					9/30/03		9/29/03		9/29/03		9/29/03	
					0310-0456		0310-0457		0310-0461		0310-0458	
		1	2									
Polychlorinated Biphenyls (PCB)												
Aroclor-1248	mg/kg	0.74	0.22	8082	1	UD	1	UD	1	UD	1	UD
Aroclor-1254	mg/kg	0.74	0.22	8082	1	UD	1	UD	1	UD	1	UD
Aroclor-1260	mg/kg	0.74	0.22	8082	1	UD	1	UD	1	UD	1	UD
PCB Total-TCL	mg/kg	0.74	0.22		1	UD	1	UD	1	UD	1	UD

D: Sample was diluted prior to analyses.

J: Concentration was estimated.

PRG: Preliminary Remediation Goal

U; Analyte not detected.

¹ USEPA Region 9 Industrial Soil Preliminary Remediation Goals.

² USEPA Region 9 Residential Soil Preliminary Remediation Goals.

³ Not Analyzed - Broken by the Laboratory

Appendix A-1

**TABLE A-1
PCB ANALYTICAL RESULTS**

Analyte	Unit	PRG for Industrial Soil	PRG for Residential Soil	Analytical Method	TP-10-4		TP-13-8		TP-14-1.5	
					9/29/03		9/30/03		9/30/03	
					0310-0459		0310-0463		0310-0464	
Polychlorinated Biphenyls (PCB)										
Aroclor-1248	mg/kg	0.74	0.22	8082	1	UD	1	UD	1	UD
Aroclor-1254	mg/kg	0.74	0.22	8082	1	UD	1	UD	1	UD
Aroclor-1260	mg/kg	0.74	0.22	8082	1	UD	1	UD	1	UD
PCB Total-TCL	mg/kg	0.74	0.22		1	UD	1	UD	1	UD

D: Sample was diluted prior to analyses.

J: Concentration was estimated.

PRG: Preliminary Remediation Goal

U; Analyte not detected.

¹ USEPA Region 9 Industrial Soil Preliminary Remediation Goals.

² USEPA Region 9 Residential Soil Preliminary Remediation Goals.

³ Not Analyzed - Broken by the Laboratory

Appendix A-2.1
Table A-2.1
Summary of IEPA Industrial Worker Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	X102 5/4/2004	X103 5/4/2004	X104 5/4/2004	X105 5/4/2004	X106 5/4/2004	X107 5/4/2004	X108 5/3/2004	X109 5/4/2004	X110 5/4/2004
Sample Type														
Sample Interval						(2.5 - 2.5)	(3 - 4)	(3 - 4)	(1 - 1.5)	(2 - 2)	(3 - 3)	(6 - 6)	(4.5 - 4.5)	(2 - 2)
PCBs														
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.037 UJ	0.033 U	0.035 UJ	0.37 U	0.42 U	0.066 U	0.037 U	0.049 U	0.044 UJ
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.074 UJ	0.068 U	0.071 UJ	0.75 U	0.86 U	0.13 U	0.076 U	0.1 U	0.09 UJ
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.037 UJ	0.033 U	0.035 UJ	0.37 U	0.42 U	0.066 U	0.037 U	0.049 U	0.044 UJ
Aroclor 1242	53468219	mg/kg	NV	1	NV	0.037 UJ	0.033 U	0.035 UJ	0.37 U	0.42 U	0.066 U	0.037 U	0.049 U	0.044 UJ
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.037 UJ	0.033 U	0.035 UJ	0.37 U	0.25 J	0.066 U	0.11 J	0.049 U	0.044 UJ
Aroclor 1254	11097681	mg/kg	NV	1	NV	0.037 UJ	0.033 U	0.035 UJ	0.37 U	0.42 U	0.066 U	0.037 U	0.049 U	0.044 UJ
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.037 UJ	0.033 U	0.035 UJ	0.37 U	0.42 U	0.066 U	0.037 U	0.049 U	0.044 UJ
Polychlorinated Biphenyls, Total	1336363	mg/kg	NV	1	NV	0.074 UJ	0.068 U	0.071 UJ	0.75 U	0.25 J	0.13 U	0.11 J	0.1 U	0.09 U

Appendix A-2.1
Table A-2.1
Summary of IEPA Industrial Worker Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	X110A 5/4/2004	X111 5/5/2004	X112 5/6/2004	X113 5/5/2004	X114 5/6/2004	X116 5/6/2004	X117 5/4/2004	X118 5/4/2004	X119 5/4/2004
<i>Sample Type</i>														
<i>Sample Interval</i>						(2 - 2)	(5 - 5)	(5 - 5)	(6 - 6)	(4 - 4)	(5 - 5)	(1 - 1.5)	(4 - 4)	(2 - 2)
PCBs														
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.045 UJ	0.046 U	0.05 U	0.41 U	0.035 U	0.4 U	0.039 U	0.67 U	0.037 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.092 UJ	0.094 U	0.1 U	0.82 U	0.07 U	0.81 U	0.079 U	1.4 U	0.076 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.045 UJ	0.046 U	0.05 U	0.41 U	0.035 U	0.4 U	0.039 U	0.67 U	0.037 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.045 UJ	0.046 U	0.05 U	0.41 U	0.035 U	0.4 U	0.039 U	0.67 U	0.037 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.045 UJ	0.046 U	0.05 U	0.41 U	0.035 U	0.4 U	0.039 U	0.67 U	0.037 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.045 UJ	0.046 U	0.05 U	0.41 U	0.035 U	0.4 U	0.039 U	0.67 U	0.037 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.045 UJ	0.046 U	0.05 U	0.41 U	0.035 U	0.4 U	0.039 U	0.67 U	0.037 U
Polychlorinated Biphenyls, Total	1336363	mg/kg	NV	1	NV	0.092 U	0.094 U	0.1 U	0.82 U	0.07 U	0.81 U	0.079 U	1.4 U	0.076 U

Appendix A-2.1
Table A-2.1
Summary of IEPA Industrial Worker Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	X120 5/4/2004	X120 5/4/2004	X121 5/3/2004	X123 5/3/2004	X126 5/5/2004	X126A 5/5/2004	X127 5/5/2004	X128 5/3/2004	X129 5/5/2004
<i>Sample Type</i>														
<i>Sample Interval</i>						(2 - 2)	(5 - 5)	(6.5 - 6.5)	(3 - 4)	(3.5 - 3.5)	(3.5 - 3.5)	(2 - 2)	(3 - 4)	(0.5 - 0.5)
PCBs														
Aroclor 1016	12674112	mg/kg	NV	1	NV		0.43 U	0.044 UJ	0.39 U	0.42 U	0.43 U	0.038 U	0.52 U	0.37 U
Aroclor 1221	11104282	mg/kg	NV	1	NV		0.87 U	0.088 UJ	0.8 U	0.86 U	0.88 U	0.077 U	1 U	0.75 U
Aroclor 1232	11141165	mg/kg	NV	1	NV		0.43 U	0.044 UJ	0.39 U	0.42 U	0.43 U	0.038 U	0.52 U	0.37 U
Aroclor 1242	53469219	mg/kg	NV	1	NV		0.43 U	0.044 UJ	0.39 U	0.42 U	0.43 U	0.038 U	0.52 U	0.37 U
Aroclor 1248	12672296	mg/kg	NV	1	NV		0.43 U	0.044 UJ	0.39 U	0.42 U	0.43 U	0.038 U	0.52 U	0.37 U
Aroclor 1254	11097691	mg/kg	NV	1	NV		0.43 U	0.044 UJ	0.39 U	0.42 U	0.43 U	0.038 U	0.52 U	0.37 U
Aroclor 1260	11096826	mg/kg	NV	1	NV		0.43 U	0.044 UJ	0.39 U	0.42 U	0.43 U	0.038 U	0.52 U	0.37 U
Polychlorinated Biphenyls, Total	1336363	mg/kg	NV	1	NV		0.87 U	0.088 UJ	0.8 U	0.86 U	0.88 U	0.077 U	1 U	0.8 U

Appendix A-2.1
Table A-2.1
Summary of IEPA Industrial Worker Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	X130 5/6/2004	X131 5/3/2004	X132 5/3/2004	X133 5/6/2004	X134 5/6/2004	X135 5/6/2004	X138 5/5/2004	X139 5/3/2004	X140 5/6/2004
Sample Type														
Sample Interval						(5.4 - 5.4)	(0 - 0.5)	(0 - 0.5)	(5.5 - 5.5)	(6.5 - 6.5)	(6.5 - 6.5)	(6 - 7)	(0 - 0.25)	(4 - 4)
PCBs														
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.5 U	0.39 U	0.34 U	0.47 U	0.052 U	0.46 U	0.45 U	0.85 U	0.53 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	1 U	0.79 U	0.69 U	0.95 U	0.11 U	0.94 U	0.91 U	1.7 U	1.1 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.5 U	0.39 U	0.34 U	0.47 U	0.052 U	0.46 U	0.45 U	0.85 U	0.53 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.5 U	0.39 U	0.34 U	0.47 U	0.052 U	0.46 U	0.45 U	0.85 U	0.53 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.5 U	0.39 U	0.34 U	0.47 U	0.052 U	0.46 U	0.45 U	0.85 U	0.53 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.5 U	1.4	0.34 J	0.47 U	0.052 U	0.46 U	0.45 U	0.85 U	0.53 U
Aroclor 1260	11086825	mg/kg	NV	1	NV	0.5 U	0.39 U	0.34 U	0.47 U	0.052 U	0.46 U	0.45 U	0.85 U	0.53 U
Polychlorinated Biphenyls, Total	1336363	mg/kg	NV	1	NV	1 U	1.4	0.34 J	1 U	0.1 U	0.9 U	0.9 U	1.7 U	1.1 U

Appendix A-2.1
Table A-2.1
Summary of IEPA Industrial Worker Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	X142 5/6/2004	X143 5/5/2004	X144 5/5/2004	X145 5/3/2004
						Sample Type			
						Sample Interval			
						(4 - 4)	(4 - 4)	(4.5 - 4.5)	(0 - 0.5)
PCBs									
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.048 U	0.42 U	0.039 U	0.33 UJ
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.096 U	0.85 U	0.079 U	0.67 UJ
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.048 U	0.42 U	0.039 U	0.33 UJ
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.048 U	0.42 U	0.039 U	0.33 UJ
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.048 U	0.42 U	0.039 U	0.33 UJ
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.048 U	0.42 U	0.039 U	0.59 J
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.048 U	0.42 U	0.039 U	0.33 UJ
Polychlorinated Biphenyls, Total	1336363	mg/kg	NV	1	NV	0.1 U	0.9 U	0.1 U	0.59 J

Appendix A-2.1
Table A-2.1 Notes
Summary of IEPA Industrial Worker Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Notes:

All units are in milligram per kilogram (mg/kg)

(a) Background values are based on concentrations of constituents in soil in counties within metropolitan statistical areas of Illinois (Appendix A of TACO, Tables G and H) (IPCB, 2013).

(b) Industrial Worker soil remediation objectives are based on values provided in the Tiered Approach to Corrective Action Objectives (TACO) - Appendix B, Table B (IPCB, 2013).

NV: No Value

FD: Field Duplicate Sample

IEPA: Illinois Environmental Protection Agency

Parameter Groups

SVOCs: Semi-volatile Organic Compounds

PCBs: Polychlorinated Biphenyls

VOCs: Volatile Organic Compounds

Qualifiers

J: The associated numerical value is an estimated quantity.

U: The chemical was analyzed for, but not detected. The associated numerical value is the reporting limit.

R: Rejected data. Rejected data were used during the risk evaluating per IEPA's request.

Bold typeface and no shading indicates a chemical was not detected, but its reporting limit exceeds the Tier 1 soil remediation objectives for the Industrial Worker for at least one exposure route.

Yellow shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for the ingestion exposure route.

Green shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for the inhalation exposure route.

Blue shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for both the ingestion and inhalation exposure routes.

**Appendix A-3.1
Table A-3.1**

**Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB001 11/8/2006	SB002 11/8/2006	SB003 11/8/2006	SB003 11/8/2006	SB004 11/17/2006	SB004 11/8/2006	SB005 11/8/2006	SB006 11/17/2006
Sample Type													
Sample Interval						(4 - 6)	(1 - 3)	(0 - 0.5)	(7 - 9)	(0 - 0.5)	(5 - 7)	(3 - 5)	(0 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.02 U	0.019 U	0.019 U	0.021 U	0.04 U	0.018 U	0.023 U	0.017 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.02 U	0.019 U	0.019 U	0.021 U	0.04 U	0.018 U	0.023 U	0.017 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.02 U	0.019 U	0.019 U	0.021 U	0.04 U	0.018 U	0.023 U	0.017 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.02 U	0.019 U	0.019 U	0.021 U	0.04 U	0.018 U	0.023 U	0.017 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.02 U	0.019 U	0.019 U	0.021 U	0.26	0.018 U	0.18	0.057
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.02 U	0.019 U	0.019 U	0.021 U	0.27	0.018 U	0.083	0.043
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.02 U	0.019 U	0.048	0.021 U	0.21	0.052	0.084	0.04

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB006 11/8/2006	SB007 11/8/2006	SB008 11/17/2006	SB008 11/17/2006	SB008 11/8/2006	SB009 11/8/2006	SB010 11/8/2006	SB011 11/8/2006
Sample Type									FD				
Sample Interval						(2 - 4)	(2 - 4)	(0 - 0.5)	(0 - 0.5)	(2 - 4)	(3 - 5)	(4 - 6)	(5 - 7)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.017 U	0.019 U	0.037 U	0.018 U	0.017 U	0.017 U		
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.017 U	0.019 U	0.037 U	0.018 U	0.017 U	0.017 U		
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.017 U	0.019 U	0.037 U	0.018 U	0.017 U	0.017 U		
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.017 U	0.019 U	0.037 U	0.018 U	0.017 U	0.017 U		
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.14	0.019 U	0.037 U	0.018 U	0.017 U	0.017 U		
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.092	0.019 U	0.037 U	0.018 U	0.041	0.017 U		
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.057	0.019 U	0.093	0.073	0.017 U	0.017 U		

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB011 11/8/2006	SB012 11/17/2006	SB012 11/17/2006	SB012 11/8/2006	SB013 11/8/2006	SB014 11/8/2006	SB016 11/7/2006	SB016 11/7/2006
Sample Type						FD		FD					
Sample Interval						(5 - 7)	(0 - 0.5)	(0 - 0.5)	(5 - 7)	(4 - 6)	(5 - 7)	(0 - 0.5)	(1 - 3)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV					0.019 U	0.02 U	0.019 U	0.02 U
Aroclor 1221	11104282	mg/kg	NV	1	NV					0.019 U	0.02 U	0.019 U	0.02 U
Aroclor 1232	11141165	mg/kg	NV	1	NV					0.019 U	0.02 U	0.019 U	0.02 U
Aroclor 1242	53469219	mg/kg	NV	1	NV					0.019 U	0.02 U	0.019 U	0.02 U
Aroclor 1248	12672296	mg/kg	NV	1	NV					0.019 U	0.02 U	0.019 U	0.02 U
Aroclor 1254	11097691	mg/kg	NV	1	NV					0.019 U	0.02 U	0.019 U	0.02 U
Aroclor 1260	11096825	mg/kg	NV	1	NV					0.019 U	0.02 U	0.046	0.024

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB017 11/17/2006	SB017 11/17/2006	SB017 11/7/2006	SB018 11/13/2006	SB020 11/9/2006	SB020 11/9/2006	SB023 11/13/2006	SB024 11/8/2006
Sample Type						FD							
Sample Interval						(0 - 0.5)	(0 - 0.5)	(5 - 6.5)	(0.5 - 1)	(6 - 8)	(8 - 9)	(0.5 - 1)	(1 - 3)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.019 U	0.019 U	0.021 U	0.019 U	0.019 U	0.024 U	0.019 U	0.019 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.019 U	0.019 U	0.021 U	0.019 U	0.019 U	0.024 U	0.019 U	0.019 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.019 U	0.019 U	0.021 U	0.019 U	0.019 U	0.024 U	0.019 U	0.019 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.019 U	0.019 U	0.021 U	0.019 U	0.019 U	0.024 U	0.019 U	0.019 U
Aroclor 1246	12672296	mg/kg	NV	1	NV	0.019 U	0.019 U	0.021 U	0.019 U	0.019 U	0.024 U	0.019 U	0.019 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.019 U	0.019 U	0.021 U	0.019 U	0.019 U	0.024 U	0.019 U	0.019 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.072	0.047	0.024	0.019 U	0.019 U	0.024 U	0.024	0.019 U

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB024 11/8/2006	SB025 11/7/2006	SB025 11/7/2006	SB026 11/7/2006	SB026 11/7/2006	SB027 11/7/2006	SB033 11/7/2006	SB034 11/7/2006
<i>Sample Type</i>						FD							
<i>Sample Interval</i>						(1 - 3)	(0 - 0.5)	(8 - 10)	(0 - 0.5)	(7 - 9)	(5 - 7)	(7 - 9)	(0 - 2)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.021 U	0.018 U	0.022 U	0.017 U	0.022 U	0.018 U	0.028 U	0.02 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.021 U	0.018 U	0.022 U	0.017 U	0.022 U	0.018 U	0.028 U	0.02 U
Aroclor 1232	11141166	mg/kg	NV	1	NV	0.021 U	0.018 U	0.022 U	0.017 U	0.022 U	0.018 U	0.028 U	0.02 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.021 U	0.018 U	0.022 U	0.017 U	0.022 U	0.018 U	0.028 U	0.02 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.021 U	0.018 U	0.022 U	0.017 U	0.022 U	0.018 U	0.028 U	0.02 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.021 U	0.018 U	0.022 U	0.023	0.022 U	0.018 U	0.028 U	0.02 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.013 J	0.029	0.022 U	0.016 J	0.022 U	0.018 U	0.028 U	0.019 J

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB035 11/7/2006	SB036 11/7/2006	SB037 11/7/2006	SB037 11/7/2006	SB038 11/7/2006	SB039 11/7/2006	SB040 11/7/2006	SB041 11/7/2006
<i>Sample Type</i>													
<i>Sample Interval</i>						(0 - 2)	(5.5 - 7.5)	(0 - 0.5)	(5 - 9)	(5 - 9)	(7.5 - 10)	(5 - 9)	(0 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.02 U	0.02 U	0.019 U	0.023 U	0.086 U	0.097 U	0.045 U	0.34 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.02 U	0.02 U	0.019 U	0.023 U	0.086 U	0.097 U	0.045 U	0.34 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.02 U	0.02 U	0.019 U	0.023 U	0.086 U	0.097 U	0.045 U	0.34 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.02 U	0.02 U	0.019 U	0.023 U	0.086 U	0.097 U	0.045 U	0.34 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.02 U	0.02 U	0.019 U	0.023 U	0.086 U	0.097 U	0.045 U	0.34 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.02 U	0.02 U	0.019 U	0.023 U	0.086 U	0.097 U	0.045 U	0.34 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.02 U	0.02 U	0.37	0.023 U	0.36	0.55	0.045 U	3.9

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB041 11/7/2006	SB041 11/7/2006	SB042 11/10/2006	SB043 11/6/2006	SB043 11/6/2006	SB044 11/6/2006	SB045 11/6/2006	SB046 11/6/2006
<i>Sample Type</i>						<i>FD</i>							
<i>Sample Interval</i>						(7.5 - 9)	(7.5 - 9)	(1 - 2)	(0 - 0.5)	(5 - 7.5)	(5 - 7.5)	(2.5 - 5)	(0 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.018 U	0.11 U	0.032 U	0.019 U	0.017 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.018 U	0.11 U	0.032 U	0.019 U	0.017 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.018 U	0.11 U	0.032 U	0.019 U	0.017 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.018 U	0.11 U	0.032 U	0.019 U	0.017 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.018 U	0.11 U	0.032 U	0.019 U	0.017 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.018 U	0.11 U	0.032 U	0.019 U	0.017 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.096 U	0.022 U	0.02 U	0.059	0.11 U	0.032 U	0.019 U	0.017 U

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB046 11/6/2006	SB047 11/6/2006	SB048 11/6/2006	SB048 11/7/2006	SB048 11/6/2006	SB049 11/6/2006	SB050 11/6/2006	SB101 10/1/2007
Sample Type									FD				
Sample Interval						(5 - 7.5)	(5 - 7.5)	(0 - 0.5)	(0 - 0.5)	(7.5 - 10)	(7.5 - 10)	(4 - 5)	(5 - 5.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.019 U	0.022 U	0.37 U	0.19 U	0.024 U	0.018 U	0.019 U	
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.019 U	0.022 U	0.37 U	0.19 U	0.024 U	0.018 U	0.019 U	
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.019 U	0.022 U	0.37 U	0.19 U	0.024 U	0.018 U	0.019 U	
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.019 U	0.022 U	0.37 U	0.19 U	0.024 U	0.018 U	0.019 U	
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.019 U	0.022 U	0.37 U	0.19 U	0.024 U	0.018 U	0.019 U	
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.019 U	0.022 U	2.9	0.19 U	0.024 U	0.018 U	0.019 U	
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.019 U	0.022 U	0.37 U	2.9	0.024 U	0.018 U	0.019 U	

**Appendix A-3.1
Table A-3.1**

**Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB102 10/1/2007	SB103 10/1/2007	SB104 10/1/2007	SB105 10/1/2007	SB106 10/2/2007	SB107 10/1/2007	SB108 10/2/2007	SB109 10/2/2007
<i>Sample Type</i>													
<i>Sample Interval</i>						(7.5 - 7.5)	(5 - 6)	(3 - 4)	(1 - 2)	(6 - 7)	(5 - 6)	(5 - 6)	(6 - 7)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV								
Aroclor 1221	11104282	mg/kg	NV	1	NV								
Aroclor 1232	11141165	mg/kg	NV	1	NV								
Aroclor 1242	53469219	mg/kg	NV	1	NV								
Aroclor 1248	12672296	mg/kg	NV	1	NV								
Aroclor 1254	11097691	mg/kg	NV	1	NV								
Aroclor 1260	11096825	mg/kg	NV	1	NV								

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Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB110 10/2/2007	SB111 10/1/2007	SB112 10/2/2007	SB113 10/2/2007	SB114 10/10/2007	SB115 10/10/2007	SB116 10/10/2007	SB117 10/10/2007
<i>Sample Type</i>													
<i>Sample Interval</i>						(6 - 7)	(1.5 - 2)	(6.5 - 7)	(6 - 7)	(7 - 8.5)	(5 - 6.5)	(7 - 7.5)	(6 - 7.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV								
Aroclor 1221	11104282	mg/kg	NV	1	NV								
Aroclor 1232	11141165	mg/kg	NV	1	NV								
Aroclor 1242	53469219	mg/kg	NV	1	NV								
Aroclor 1248	12672296	mg/kg	NV	1	NV								
Aroclor 1254	11097691	mg/kg	NV	1	NV								
Aroclor 1260	11096625	mg/kg	NV	1	NV								

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB118 10/10/2007	SB119 10/10/2007	SB-121 2/11/2008	SB-122 2/11/2008	SB-123 2/11/2008	SB-124 2/11/2008	SB-125 2/11/2008	SB-126 2/11/2008
<i>Sample Type</i>													
<i>Sample Interval</i>						(7 - 9.5)	(6.5 - 8)	(8 - 9)	(8 - 9)	(8 - 12)	(8 - 9)	(8 - 9)	(8 - 9)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV								
Aroclor 1221	11104282	mg/kg	NV	1	NV								
Aroclor 1232	11141165	mg/kg	NV	1	NV								
Aroclor 1242	53469219	mg/kg	NV	1	NV								
Aroclor 1248	12672296	mg/kg	NV	1	NV								
Aroclor 1254	11097691	mg/kg	NV	1	NV								
Aroclor 1260	11096825	mg/kg	NV	1	NV								

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SB-127 2/11/2008	SB1E 11/9/2006	SB1N 11/9/2006	SB2S 11/10/2006	SB2W 11/9/2006	SB3N 11/10/2006	SG001 11/14/2006	SG002 11/14/2006
Sample Type													
Sample Interval						(4 - 8)	(8 - 9)	(11 - 12)	(6 - 7)	(4 - 6)	(7 - 9)	(0.25 - 0.5)	(0.25 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U
Aroclor 1221	11104282	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U
Aroclor 1232	11141165	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U
Aroclor 1242	53469219	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U
Aroclor 1248	12672286	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U
Aroclor 1254	11097691	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U
Aroclor 1260	11096825	mg/kg	NV	1	NV		0.017 U	0.018 U	0.023 U	0.018 U	0.022 U	0.019 U	0.02 U

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Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG003 11/14/2006	SG004 11/14/2006	SG005 11/14/2006	SG006 11/14/2006	SG007 11/14/2006	SG007 11/14/2006	SG008 11/14/2006	SG008W 11/14/2006
<i>Sample Type</i>											FD		
<i>Sample Interval</i>						(0.25 - 0.5)	(0.167 - 0.25)	(0.333 - 0.417)	(0.083 - 0.167)	-0.5	-0.5	-0.5	(0.333 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.019 U	0.18 U	0.019 U	0.18 U	0.022 U	0.022 U	0.019 U	
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.019 U	0.18 U	0.019 U	0.18 U	0.022 U	0.022 U	0.019 U	
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.019 U	0.18 U	0.019 U	0.18 U	0.022 U	0.022 U	0.019 U	
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.019 U	0.18 U	0.019 U	0.18 U	0.022 U	0.022 U	0.019 U	
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.019 U	0.51	0.019 U	2.2	0.022 U	0.022 U	0.019 U	
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.019 U	0.18 U	0.13	1.5	0.089	0.096	0.023	
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.036	2.3	0.082	0.35	0.062	0.072	0.035	

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Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG009 11/16/2006	SG009E 11/16/2006	SG010 11/16/2006	SG010E 11/16/2006	SG011 11/15/2006	SG012 11/15/2006	SG012N 11/15/2006	SG013 11/15/2006
Sample Type													
Sample Interval						(0.25 - 0.333)	(0.417 - 0.5)	(0.417 - 0.5)	(0.333 - 0.417)	(0.167 - 0.25)	(0.25 - 0.333)	(0.167 - 0.25)	(0.417 - 0.583)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.017 U		0.035 U		0.018 U	0.018 U		0.02 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.017 U		0.035 U		0.018 U	0.018 U		0.02 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.017 U		0.035 U		0.018 U	0.018 U		0.02 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.017 U		0.035 U		0.032	0.041		0.02 U
Aroclor 1248	12672286	mg/kg	NV	1	NV	0.017 U		0.39		0.018 U	0.018 U		0.02 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.017 U		0.035 U		0.06	0.031		0.049
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.02		0.035 U		0.045	0.018 J		0.06

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG013 11/15/2006	SG014 11/15/2006	SG015 11/15/2006	SG015E 11/15/2006	SG016 11/15/2006	SG016W 11/15/2006	SG017 11/15/2006	SG017 11/15/2006
Sample Type						FD							FD
Sample Interval						(0.417 - 0.583)	(0.25 - 0.333)	(0.25 - 0.417)	(0.167 - 0.25)	(0.25 - 0.333)	(0.167 - 0.25)	(0.25 - 0.333)	(0.25 - 0.333)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.018 U	0.091 U	0.018 U		0.017 U		0.018 U	0.018 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.018 U	0.091 U	0.018 U		0.017 U		0.018 U	0.018 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.018 U	0.091 U	0.018 U		0.017 U		0.018 U	0.018 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.018 U	0.091 U	0.016 J		0.017 U		0.018 U	0.018 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.018 U	0.091 U	0.018 U		0.017 U		0.018 U	0.018 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.031	0.29	0.06		0.017 U		0.018 U	0.018 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.039	0.3	0.077		0.017 U		0.032	0.023

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG018 11/15/2006	SG018S 11/15/2006	SG019 11/16/2006	SG019 11/16/2006	SG019E 11/16/2006	SG020 11/16/2006	SG021 11/16/2006	SG021N 11/16/2006
<i>Sample Type</i>						FD							
<i>Sample Interval</i>						(0.167 - 0.25)	(0.333 - 0.417)	(0.167 - 0.25)	(0.167 - 0.25)	(0.167 - 0.25)	(0.333 - 0.417)	(0.25 - 0.333)	(0.083 - 0.167)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.021 U		0.19 U	0.039 U		0.018 U	0.93 U	
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.021 U		0.19 U	0.039 U		0.018 U	0.93 U	
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.021 U		0.19 U	0.039 U		0.018 U	0.93 U	
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.021 U		0.19 U	0.039 U		0.018 U	0.93 U	
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.021 U		0.19 U	0.039 U		0.018 U	0.93 U	
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.021 U		0.19 U	0.039 U		0.018 U	0.93 U	
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.077		0.8	0.2		0.071	7.7	

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG022 11/16/2006	SG023 11/16/2006	SG023E 11/16/2006	SG024 11/16/2006	SG025 11/16/2006	SG025N 11/16/2006	SG026 11/16/2006	SG026W 11/16/2006
<i>Sample Type</i>													
<i>Sample Interval</i>						(0.25 - 0.333)	(0.25 - 0.333)	(0.25 - 0.333)	(0.333 - 0.417)	(0.25 - 0.333)	(0.167 - 0.25)	(0.083 - 0.167)	(0.167 - 0.25)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.019 U	0.02 U		0.02 U	0.091 U		0.018 U	
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.019 U	0.02 U		0.02 U	0.091 U		0.018 U	
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.019 U	0.02 U		0.02 U	0.091 U		0.018 U	
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.019 U	0.02 U		0.02 U	0.091 U		0.018 U	
Aroclor 1248	12672298	mg/kg	NV	1	NV	0.019 U	0.02 U		0.02 U	0.091 U		0.018 U	
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.019 U	0.02 U		0.02 U	0.091 U		0.018 U	
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.013 J	0.12		0.015 J	0.37		0.017 J	

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG101 10/2/2007	SG102 10/1/2007	SG103 10/1/2007	SG104 10/1/2007	SG105 10/1/2007	SG106 10/2/2007	SG106 10/2/2007	SG107 10/1/2007
<i>Sample Type</i>													
<i>Sample Interval</i>						(2)	(0 - 0.5)	(0 - 0.5)	(0 - 0.5)	(0 - 0.5)	(2)	(3)	(0 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.017 U	0.092 U	0.018 U	0.017 U	0.018 U	0.17 U	0.17 U	3.6 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.017 U	0.092 U	0.018 U	0.017 U	0.018 U	0.17 U	0.17 U	3.6 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.017 U	0.092 U	0.018 U	0.017 U	0.018 U	0.17 U	0.17 U	3.6 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.017 U	0.092 U	0.018 U	0.017 U	0.018 U	0.17 U	0.17 U	3.6 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.017 U	0.092 U	0.05	0.088	0.15	3.4	2.6	38
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.048	0.092 U	0.018 U	0.2	0.018 U	0.17 U	0.17 U	3.6 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.047	1.7	0.082	0.11	0.27	0.65	0.57	3.4 J

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG108 10/1/2007	SG109 10/1/2007	SG110 10/1/2007	SG111 10/2/2007	SG112 10/2/2007	SG113 10/2/2007	SG114 10/2/2007	SG115 10/2/2007
<i>Sample Type</i>													
<i>Sample Interval</i>						(0 - 0.5)	(0 - 0.5)	(0 - 0.5)	(2)	(0 - 0.5)	(0 - 0.5)	(0 - 0.5)	(0 - 0.5)
PCBs													
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.089 U	0.17 U	0.18 U	0.018 U	0.086 U	0.033 U	0.096 U	0.1 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.089 U	0.17 U	0.18 U	0.018 U	0.086 U	0.033 U	0.096 U	0.1 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.089 U	0.17 U	0.18 U	0.018 U	0.086 U	0.033 U	0.096 U	0.1 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.089 U	0.17 U	0.18 U	0.018 U	0.086 U	0.033 U	0.096 U	0.1 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.52	2	3.4	0.018 U	0.086 U	0.033 U	0.096 U	0.1 U
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.089 U	0.17 U	0.18 U	0.018 U	0.086 U	0.033 U	0.096 U	0.1 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.14	0.46	0.39	0.015 J	0.77	0.39	1.4	0.15

Appendix A-3.1
Table A-3.1

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	CAS	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route (b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route (b)	SG116 10/2/2007	SG117 10/2/2007	SG118 10/2/2007	SG119 10/2/2007	SG120 10/2/2007
<i>Sample Type</i>										
<i>Sample Interval</i>						(2.5)	(0 - 0.5)	(0 - 0.5)	(0 - 0.5)	(0 - 0.5)
PCBs										
Aroclor 1016	12674112	mg/kg	NV	1	NV	0.019 U	0.017 U	0.036 U	0.35 U	0.19 U
Aroclor 1221	11104282	mg/kg	NV	1	NV	0.019 U	0.017 U	0.036 U	0.35 U	0.19 U
Aroclor 1232	11141165	mg/kg	NV	1	NV	0.019 U	0.017 U	0.036 U	0.35 U	0.19 U
Aroclor 1242	53469219	mg/kg	NV	1	NV	0.019 U	0.017 U	0.036 U	0.35 U	0.19 U
Aroclor 1248	12672296	mg/kg	NV	1	NV	0.019 U	0.017 U	0.23	0.35 U	1
Aroclor 1254	11097691	mg/kg	NV	1	NV	0.019 U	0.16	0.52	6.6	0.19 U
Aroclor 1260	11096825	mg/kg	NV	1	NV	0.019 U	0.24	0.39	2.5	1.5

Appendix A-3.1
Table A-3.1 Notes

Summary of CEC Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Notes:

All units are in milligram per kilogram (mg/kg)

(a) Background values are based on concentrations of constituents in soil in counties within metropolitan statistical areas of Illinois (Appendix A of TACO, Tables G and H) (IPCB, 2013).

(b) Industrial Worker soil remediation objectives are based on values provided in the Tiered Approach to Corrective Action Objectives (TACO) - Appendix B, Table B (IPCB, 2013).

NV: No Value

FD: Field Duplicate Sample

Parameter Groups

SVOCs: Semi-volatile Organic Compounds

PCBs: Polychlorinated Biphenyls

VOCs: Volatile Organic Compounds




Qualifiers

J: The associated numerical value is an estimated quantity.

U: The chemical was analyzed for, but not detected. The associated numerical value is the reporting limit.

R: Rejected data

Bold typeface and no shading indicates a chemical was not detected, but its reporting limit exceeds the Tier 1 soil remediation objectives for the Industrial Worker for at least one exposure route.

	Yellow shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for the ingestion exposure route.
	Green shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for the inhalation exposure route.
	Blue shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for both the ingestion and inhalation exposure routes.

Appendix A-3.2
Table A-3.2

Summary of CEC Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-101D 2/20/2008	MW-101D 5/8/2008	MW-101S 10/22/2007	MW-101S 2/20/2008	MW-101S 5/8/2008	MW-102D 2/21/2008	MW-102D 5/12/2008	MW-102S 10/22/2007	MW-102S 2/26/2008	MW-102S 5/9/2008	MW-103S 10/25/2007	MW-103S 2/25/2008
<i>Sample Type</i>														
PCBs														
Aroclor-1016	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Aroclor-1221	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Aroclor-1232	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Aroclor-1242	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Aroclor-1248	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Aroclor-1254	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Aroclor-1260	mg/L	0.0005	0.0005 U	0.00051 U	0.00049 U	0.00051 U	0.00053 U	0.0005 U	0.0005 U	0.00049 U	0.00053 U	0.00051 U	0.00049 U	0.00049 U
Polychlorinated biphenyls, Total	mg/L	0.0005		0.00051 U			0.00053 U		0.0005 U			0.00051 U		

Appendix A-3.2
Table A-3.2

Summary of CEC Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-103S 2/25/2008	MW-103S 5/8/2008	MW-104D 2/21/2008	MW-104D 5/9/2008	MW-104D 5/9/2008	MW-104S 10/23/2007	MW-104S 2/25/2008	MW-104S 5/9/2008	MW-105S 10/23/2007	MW-105S 10/23/2007	MW-105S 2/19/2008	MW-105S 5/7/2008
		Sample Type	FD				FD					FD		
PCBs														
Aroclor-1016	mg/L	0.0005	0.00047 U	0.00051 U	0.00048 U	0.0005 U	0.00052 U	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Aroclor-1221	mg/L	0.0005	0.00047 U	0.00051 U	0.00048 U	0.0005 U	0.00052 U	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Aroclor-1232	mg/L	0.0005	0.00047 U	0.00051 U	0.00048 U	0.0005 U	0.00052 U	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Aroclor-1242	mg/L	0.0005	0.00047 U	0.00051 U	0.00077	0.00029 J	0.00018 J	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Aroclor-1248	mg/L	0.0005	0.00047 U	0.00051 U	0.00048 U	0.0005 U	0.00052 U	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Aroclor-1254	mg/L	0.0005	0.00047 U	0.00051 U	0.00048 U	0.0005 U	0.00052 U	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Aroclor-1260	mg/L	0.0005	0.00047 U	0.00051 U	0.00048 U	0.0005 U	0.00052 U	0.0006 U	0.0005 U	0.00051 U	0.00047 U	0.0005 U	0.00048 U	0.0005 U
Polychlorinated biphenyls, Total	mg/L	0.0005		0.00051 U		0.00029 J	0.00018 J			0.00051 U				0.0005 U

Appendix A-3.2
Table A-3.2

Summary of CEC Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-105S 5/7/2008	MW-107S 10/23/2007	MW-107S 2/20/2008	MW-107S 5/8/2008	MW-2 2/25/2008	MW-2 5/7/2008	MW-3 10/23/2007	MW-3 2/26/2008	MW-3 5/7/2008	MW-4D 2/21/2008	MW-4D 5/13/2008
		Sample Type	FD										
PCBs													
Aroclor-1016	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Aroclor-1221	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Aroclor-1232	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Aroclor-1242	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Aroclor-1248	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Aroclor-1254	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Aroclor-1260	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U
Polychlorinated biphenyls, Total	mg/L	0.0005	0.00051 U	0.00047 U	0.00048 U	0.00048 U	0.00049 U	0.0005 U	0.0005 U	0.0005 U	0.00047 U	0.00049 U	0.00052 U

**Appendix A-3.2
Table A-3.2 Notes**

**Summary of CEC Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Notes:

FD: Field Duplicate

NV: No Value

Parameter Groups

PCBs: Polychlorinated Biphenyls

SVOCs: Semi-volatile Organic Compounds

VOCs: Volatile Organic Compounds


Qualifiers

B: Analyte was detected in the blank sample.

J: The associated numerical value is an estimated quantity.

U: The chemical was analyzed for, but not detected. The associated numerical value is the reporting limit.

Bold typeface and no shading indicates a chemical was not detected, but its reporting limit exceeds the Tier 1 Groundwater Remediation Objective.

 **Yellow shading indicates detected concentration exceeds the Tier 1 Groundwater Remediation Objective.**

Appendix A-4
Table A-4

Summary of URS Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-101D 12/2/2008	MW-101D 3/10/2009	MW-101D 3/10/2009	MW-101S 12/3/2008	MW-102D 12/2/2008	MW-102D 3/10/2009	MW-102S 12/2/2008	MW-103S 12/3/2008	MW-104D 12/2/2008	MW-104D 3/10/2009	MW-104S 12/3/2008	MW-105S 12/3/2008
Sample Type					FD									
PCBs														
Aroclor-1016	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U
Aroclor-1221	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U
Aroclor-1232	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U
Aroclor-1242	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U
Aroclor-1246	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00026 J	0.00048 U	0.00047 U
Aroclor-1254	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U
Aroclor-1260	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U
Polychlorinated biphenyls, Total	mg/L	0.0005	0.00047 U	0.00047 U	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00026 J	0.00048 U	0.00047 U

**Appendix A-4
Table A-4**

**Summary of URS Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-107S 12/3/2008	MW-4 12/2/2008	MW-4D 12/2/2008	MW-4D 12/2/2008	MW-4D 3/10/2009	MW-701S 12/3/2008	MW-701S 12/3/2008	MW-702S 12/3/2008	MW-703S 12/3/2008
		Sample Type				FD			FD		
PCBs											
Aroclor-1016	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 UJ	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Aroclor-1221	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Aroclor-1232	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Aroclor-1242	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Aroclor-1248	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Aroclor-1254	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Aroclor-1260	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U
Polychlorinated biphenyls, Total	mg/L	0.0005	0.00047 U	0.00047 U	0.00048 U	0.00047 U	0.00047 U	0.00048 U	0.00048 U	0.00047 U	0.00047 U

Appendix A-4
Table A-4 Notes

Summary of URS Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Notes:

FD: Field Duplicate

NV: No Value

Parameter Groups

PCBs: Polychlorinated Biphenyls

SVOCs: Semi-volatile Organic Compounds

VOCs: Volatile Organic Compounds

Qualifiers

J: The associated numerical value is an estimated quantity.

U: The chemical was analyzed for, but not detected. The associated numerical value is the reporting limit.

Bold typeface and no shading indicates a chemical was not detected, but its reporting limit exceeds the Tier 1 Groundwater Remediation Objective.

 **Yellow shading** indicates detected concentration exceeds the Tier 1 Groundwater Remediation Objective.

**Appendix A-5.1
Table A-5.1**

**Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB201-SB-01-04042013	SB201-SB-02-04042013	SB201-SS-04042013	SB202-SB-01-04042013	SB202-SB-02-04042013	SB202-SS-04042013	SB203-SB-01-04042013
Sample Type											
Sample Interval					(1.5 - 2.5)	(5.5 - 6.5)	(0 - 0.5)	(1.5 - 2.5)	(5.5 - 6.5)	(0 - 0.5)	(1.5 - 2.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.02 U	0.02 U	0.019 U	0.02 U
Aroclor 1221	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.02 U	0.02 U	0.019 U	0.02 U
Aroclor 1232	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.02 U	0.02 U	0.019 U	0.02 U
Aroclor 1242	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.02 U	0.02 U	0.019 U	0.02 U
Aroclor 1248	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.02 U	0.02 U	0.019 U	0.02 U
Aroclor 1254	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.02	0.028	0.019 U	0.02 U
Aroclor 1260	mg/kg	NV	1	NV	0.019 UJ	0.019 UJ	0.018 UJ	0.026 J	0.032 J	0.019 UJ	0.091 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.019 U	0.019 U	0.018 U	0.045	0.056	0.019 U	0.091

Appendix A-5.1

Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB203-SB-02-04042013	SB203-SS-04042013	SB205-SB-01-04042013	SB205-SS-04042013	SB206-SB-01-04042013	SB206-SB-02-04042013	SB206-SS-04042013
Sample Type											
Sample Interval					(3.5 - 4.5)	(0 - 0.5)	(1.5 - 2.5)	(0 - 0.5)	(1.5 - 2.5)	(3.5 - 4.5)	(0 - 0.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.02 U	0.019 U	0.02 U	0.018 U	0.018 U	0.019 U	0.018 U
Aroclor 1221	mg/kg	NV	1	NV	0.02 U	0.019 U	0.02 U	0.018 U	0.018 U	0.019 U	0.018 U
Aroclor 1232	mg/kg	NV	1	NV	0.02 U	0.019 U	0.02 U	0.018 U	0.018 U	0.019 U	0.018 U
Aroclor 1242	mg/kg	NV	1	NV	0.02 U	0.019 U	0.02 U	0.018 U	0.018 U	0.019 U	0.018 U
Aroclor 1248	mg/kg	NV	1	NV	0.02 U	0.019 U	0.02 U	0.018 U	0.018 U	0.019 U	0.018 U
Aroclor 1254	mg/kg	NV	1	NV	0.02 U	0.019 U	0.02 U	0.018 U	0.018 U	0.019 U	0.16
Aroclor 1260	mg/kg	NV	1	NV	0.02 UJ	0.12 J	0.02 UJ	0.07 J	0.018 UJ	0.019 UJ	0.1 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.02 U	0.12	0.02 U	0.07	0.018 U	0.019 U	0.26

Appendix A-5.1
Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB207-SB-01-04052013	SB207-SB-02-04052013	SB207-SS-04052013	SB208-SB-01-04042013	SB208-SB-02-04042013	SB208-SS-04042013	SB208-SS-04042013
Sample Type											
Sample Interval					(1.5 - 2.5)	(4.5 - 5.5)	(0 - 0.5)	(1.5 - 2.5)	(3.5 - 4.5)	(0 - 0.5)	FD (0 - 0.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.18 U	0.018 U	44 U	0.019 U	0.018 U	0.018 U	0.019 U
Aroclor 1221	mg/kg	NV	1	NV	0.18 U	0.018 U	44 U	0.019 U	0.018 U	0.018 U	0.019 U
Aroclor 1232	mg/kg	NV	1	NV	0.18 U	0.018 U	44 U	0.019 U	0.018 U	0.018 U	0.019 U
Aroclor 1242	mg/kg	NV	1	NV	0.18 U	0.018 U	44 U	0.019 U	0.018 U	0.018 U	0.019 U
Aroclor 1248	mg/kg	NV	1	NV	1.9	0.018 U	450	0.019 U	0.018 U	0.018 U	0.019 U
Aroclor 1254	mg/kg	NV	1	NV	0.4	0.018 U	100	0.015 J	0.018 U	0.015 J	0.019
Aroclor 1260	mg/kg	NV	1	NV	0.17 J	0.018 UJ	35 J	0.023 J	0.018 UJ	0.024 J	0.039 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	2.4	0.018 U	585	0.041	0.018 U	0.039	0.056

Appendix A-5.1
Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB209-SB-01-04082013	SB209-SB-01-04082013	SB209-SB-02-04082013	SB209-SS-04082013	SB210-SB-01-04082013	SB210-SB-02-04082013	SB210-SS-04082013
Sample Type					FD						
Sample Interval					(1.5 - 2.5)	(1.5 - 2.5)	(2.5 - 3.5)	(0 - 0.5)	(1.5 - 2.5)	(2.5 - 3.5)	(0 - 0.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Aroclor 1221	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Aroclor 1232	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Aroclor 1242	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Aroclor 1248	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Aroclor 1254	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Aroclor 1260	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.018 U	0.017 U	0.019 U	0.018 U	0.019 U	0.02 U	0.017 U

**Appendix A-5.1
Table A-5.1**

**Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB211-SB-01-04052013	SB211-SB-02-04052013	SB211-SS-04052013	SB212-SB-01-04052013	SB212-SB-02-04052013	SB212-SS-04052013	SB212-SS-04052013
Sample Type											FD
Sample Interval					(1.5 - 2.5)	(4.5 - 5.5)	(0 - 0.5)	(1.5 - 2.5)	(4.5 - 5.5)	(0 - 0.5)	(0 - 0.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.019 U	0.02 U	0.019 U	0.019 U
Aroclor 1221	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.019 U	0.02 U	0.019 U	0.019 U
Aroclor 1232	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.019 U	0.02 U	0.019 U	0.019 U
Aroclor 1242	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.019 U	0.02 U	0.019 U	0.019 U
Aroclor 1248	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.019 U	0.02 U	0.019 U	0.019 U
Aroclor 1254	mg/kg	NV	1	NV	0.017 U	0.018 U	0.025 U	0.019 U	0.02 U	0.019 U	0.013 J
Aroclor 1260	mg/kg	NV	1	NV	0.017 UJ	0.018 UJ	0.028 J	0.019 UJ	0.02 UJ	0.39 J	0.021 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.017 U	0.018 U	0.052	0.019 U	0.02 U	0.39 J	0.034 J

Appendix A-5.1
Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB213-SB-01-04042013	SB213-SS-04042013	SB214-SB-01-04042013	SB214-SB-01-04042013	SB214-SB-02-04042013	SB214-SS-04042013	SB215-SB-01-04052013
Sample Type								FD			
Sample Interval					(1.5 - 2.5)	(0 - 0.5)	(1.5 - 2.5)	(1.5 - 2.5)	(3.5 - 4.5)	(0 - 0.5)	(1.5 - 2.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.021 U	0.021 U	0.018 U	0.019 U	0.019 U	0.019 U	0.017 U
Aroclor 1221	mg/kg	NV	1	NV	0.021 U	0.021 U	0.018 U	0.019 U	0.019 U	0.019 U	0.017 U
Aroclor 1232	mg/kg	NV	1	NV	0.021 U	0.021 U	0.018 U	0.019 U	0.019 U	0.019 U	0.017 U
Aroclor 1242	mg/kg	NV	1	NV	0.021 U	0.021 U	0.018 U	0.019 U	0.019 U	0.019 U	0.017 U
Aroclor 1248	mg/kg	NV	1	NV	0.021 U	0.021 U	0.018 U	0.019 U	0.019 U	0.019 U	0.06
Aroclor 1254	mg/kg	NV	1	NV	0.021 U	0.059	0.018 U	0.019 U	0.019 U	0.098	0.016 J
Aroclor 1260	mg/kg	NV	1	NV	0.021 UJ	0.14 J	0.018 UJ	0.019 UJ	0.019 UJ	0.14 J	0.013 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.021 U	0.19	0.018 U	0.019 U	0.019 U	0.24	0.089

Appendix A-5.1
Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB215-SB-02-04052013	SB215-SS-04052013	SB216-SB-01-04052013	SB216-SB-02-04052013	SB216-SS-04052013	SB217-SB-01-04052013	SB217-SB-02-04052013
Sample Type											
Sample Interval					(2.5 - 3.5)	(0 - 0.5)	(1.5 - 2.5)	(2.5 - 3.5)	(0 - 0.5)	(1.5 - 2.5)	(4.5 - 5.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.018 U	0.017 U	0.017 U	0.018 U	0.018 U	0.018 U	0.02 U
Aroclor 1221	mg/kg	NV	1	NV	0.018 U	0.017 U	0.017 U	0.018 U	0.018 U	0.018 U	0.02 U
Aroclor 1232	mg/kg	NV	1	NV	0.018 U	0.017 U	0.017 U	0.018 U	0.018 U	0.018 U	0.02 U
Aroclor 1242	mg/kg	NV	1	NV	0.018 U	0.017 U	0.017 U	0.018 U	0.018 U	0.018 U	0.02 U
Aroclor 1248	mg/kg	NV	1	NV	0.018 U	0.017 U	0.017 U	0.018 U	0.018 U	0.018 U	0.02 U
Aroclor 1254	mg/kg	NV	1	NV	0.018 U	0.0085 J	0.017 U	0.018 U	0.018 U	0.018 U	0.065
Aroclor 1260	mg/kg	NV	1	NV	0.018 UJ	0.017 J	0.017 UJ	0.018 UJ	0.018 UJ	0.018 UJ	0.063 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.018 U	0.025	0.017 U	0.018 U	0.018 U	0.018 U	0.2

**Appendix A-5.1
Table A-5.1**

**Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB217-SS-04052013	SB218-SB-01-04052013	SB218-SB-02-04052013	SB218-SS-04052013	SB219-SB-01-04082013	SB219-SB-02-04082013	SB219-SS-04082013
Sample Type											
Sample Interval					(0 - 0.5)	(1.5 - 2.5)	(4 - 5)	(0 - 0.5)	(1.5 - 2.5)	(4.5 - 5.5)	(0 - 0.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 U	0.019 U	0.019 U
Aroclor 1221	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 U	0.019 U	0.019 U
Aroclor 1232	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 U	0.019 U	0.019 U
Aroclor 1242	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 U	0.019 U	0.019 U
Aroclor 1248	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 U	0.019 U	0.11 J
Aroclor 1254	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 U	0.019 U	0.068 J
Aroclor 1260	mg/kg	NV	1	NV	0.017 UJ	0.018 UJ	0.017 UJ	0.018 UJ	0.018 UJ	0.019 UJ	0.11 J
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.017 U	0.018 U	0.017 U	0.018 U	0.018 UJ	0.019 UJ	0.28 J

Appendix A-5.1
Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB219-SS-04082013	SB222-SB-01-04082013	SB222-SB-02-04082013	SB222-SS-04082013	SB224-SB-01-04082013	SB224-SB-02-04082013	SB224-SS-04082013
Sample Type					FD						
Sample Interval					(0 - 0.5)	(1.5 - 2.5)	(3.5 - 4.5)	(0 - 0.5)	(1.5 - 2.5)	(3.5 - 4.5)	(0 - 0.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.019 U	0.02 U	0.02 U	0.019 U	0.018 U	0.017 U	0.018 U
Aroclor 1221	mg/kg	NV	1	NV	0.019 U	0.02 U	0.02 U	0.019 U	0.018 U	0.017 U	0.018 U
Aroclor 1232	mg/kg	NV	1	NV	0.019 U	0.02 U	0.02 U	0.019 U	0.018 U	0.017 U	0.018 U
Aroclor 1242	mg/kg	NV	1	NV	0.019 U	0.02 U	0.02 U	0.019 U	0.018 U	0.017 U	0.018 U
Aroclor 1248	mg/kg	NV	1	NV	0.019 UJ	0.02 U	0.02 U	0.019 U	0.035	0.017 U	0.018 U
Aroclor 1254	mg/kg	NV	1	NV	0.019 UJ	0.02 U	0.02 U	0.019 U	0.029	0.017 U	0.018 U
Aroclor 1260	mg/kg	NV	1	NV	0.019 UJ	0.02 UJ	0.02 UJ	0.019 UJ	0.034 J	0.017 UJ	0.018 UJ
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.019 UJ	0.02 UJ	0.02 UJ	0.019 UJ	0.098	0.017 UJ	0.018 UJ

Appendix A-5.1
Table A-5.1

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB226-SB-01-04052013	SB226-SS-04052013	SB227-SB-01-04052013	SB227-SB-01-04052013	SB227-SB-02-04052013	SB227-SS-04052013	SB229-SB-01-04082013
Sample Type					Sample Interval		FD				
					(1.5 - 2.5)	(0 - 0.5)	(1.5 - 2.5)	(1.5 - 2.5)	(3 - 4)	(0 - 0.5)	(1.5 - 2.5)
PCBs											
Aroclor 1016	mg/kg	NV	1	NV	0.019 U	0.019 U	0.019 U	0.019 UJ	0.02 U	0.018 U	0.02 U
Aroclor 1221	mg/kg	NV	1	NV	0.019 U	0.019 U	0.019 U	0.019 UJ	0.02 U	0.018 U	0.02 U
Aroclor 1232	mg/kg	NV	1	NV	0.019 U	0.019 U	0.019 U	0.019 UJ	0.02 U	0.018 U	0.02 U
Aroclor 1242	mg/kg	NV	1	NV	0.019 U	0.019 U	0.019 U	0.019 UJ	0.02 U	0.018 U	0.02 U
Aroclor 1248	mg/kg	NV	1	NV	0.019 U	0.019 U	0.019 U	0.019 UJ	0.02 U	0.018 U	0.02 U
Aroclor 1254	mg/kg	NV	1	NV	0.014 J	0.015 J	0.019 UJ	0.07 J	0.02 U	0.017 J	0.02 U
Aroclor 1260	mg/kg	NV	1	NV	0.021 J	0.025 J	0.015 J	0.091 J	0.02 UJ	0.027 J	0.02 UJ
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.035	0.04	0.015 J	0.16 J	0.02 U	0.043	0.02 UJ

**Appendix A-5.1
Table A-5.1**

**Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker**

**Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois**

Parameter	Units	Background (a)	Tier 1 Soil Remediation Objectives for Industrial Worker Ingestion Route ^(b)	Tier 1 Soil Remediation Objectives for Industrial Worker Inhalation Route ^(b)	SB229-SB-01- 04082013	SB229-SS- 04082013
Sample Type					FD	
Sample Interval					(1.5 - 2.5)	(0 - 0.5)
PCBs						
Aroclor 1016	mg/kg	NV	1	NV	0.018 U	0.018 U
Aroclor 1221	mg/kg	NV	1	NV	0.018 U	0.018 U
Aroclor 1232	mg/kg	NV	1	NV	0.018 U	0.018 U
Aroclor 1242	mg/kg	NV	1	NV	0.018 U	0.018 U
Aroclor 1248	mg/kg	NV	1	NV	0.018 U	0.018 U
Aroclor 1254	mg/kg	NV	1	NV	0.018 U	0.018 U
Aroclor 1260	mg/kg	NV	1	NV	0.018 UJ	0.018 UJ
Polychlorinated biphenyls, Total	mg/kg	NV	1	NV	0.018 UJ	0.018 UJ

Appendix A-5.1
Table A-5.1 Notes

Summary of URS Soil Analytical Data
Comparison to Tier 1 Soil Ingestion and Inhalation Exposure Route for the Industrial Worker

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Notes:

All units are in milligram per kilogram (mg/kg)

(a) Background values are based on concentrations of constituents in soil in counties within metropolitan statistical areas of Illinois (Appendix A of TACO, Tables G and H) (IPCB, 2013).

(b) Industrial Worker soil remediation objectives are based on values provided in the Tiered Approach to Corrective Action Objectives (TACO) - Appendix B, Table B (IPCB, 2013).

NV: No Value

FD: Field Duplicate Sample

Parameter Groups

SVOs: Semi-volatile Organic Compounds

PCBs: Polychlorinated Biphenyls

VOCs: Volatile Organic Compounds

Qualifiers

J: The associated numerical value is an estimated quantity.

U: The chemical was analyzed for, but not detected. The associated numerical value is the reporting limit.

Bold typeface and no shading indicates a chemical was not detected, but its reporting limit exceeds the Tier 1 soil remediation objectives for the Industrial Worker for at least one exposure route.

Yellow shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for the ingestion exposure route.
Green shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for the inhalation exposure route.
Blue shading indicates detected concentration exceeds the Tier 1 soil remediation objectives for the Industrial Worker for both the ingestion and inhalation exposure routes.

Appendix A-5.2
Table A-5.2

Summary of URS Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-1 4/12/2013	MW-101D 4/15/2013	MW-101S 4/15/2013	MW-101S 4/15/2013	MW-102D 4/15/2013	MW-102S 4/15/2013	MW-103S 4/11/2013	MW-104D 4/15/2013	MW-104S 4/15/2013	MW-105S 4/11/2013	MW-107S 4/11/2013	MW-2 4/11/2013
Sample Type					FD									
PCBs														
Aroclor-1016	mg/L	0.0005	0.00038 UJ	0.00038 UJ	0.00039 UJ	0.00039 UJ	0.00039 UJ	0.00041 UJ	0.00039 UJ	0.00039 UJ	0.00039 UJ	0.0004 UJ	0.00038 UJ	0.00038 UJ
Aroclor-1221	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U
Aroclor-1232	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U
Aroclor-1242	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U
Aroclor-1248	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U
Aroclor-1254	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U
Aroclor-1260	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U
Polychlorinated biphenyls, Total	mg/L	0.0005	0.00038 U	0.00038 U	0.00039 U	0.00039 U	0.00039 U	0.00041 U	0.00039 U	0.00039 U	0.00039 U	0.0004 U	0.00038 U	0.00038 U

Appendix A-5.2
Table A-5.2

Summary of URS Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Parameter	Units	Tier 1 Groundwater Remediation Objective (Class I)	MW-201D 4/12/2013	MW-201S 4/12/2013	MW-201S 4/12/2013	MW-202D 4/12/2013	MW-202S 4/12/2013	MW-3 4/11/2013	MW-4 4/15/2013	MW-4 4/15/2013
		Sample Type			FD					
PCBs										
Aroclor-1016	mg/L	0.0005	0.00039 UJ	0.00038 UJ	0.00039 UJ	0.00038 UJ	0.00038 UJ	0.00038 UJ	0.00039 UJ	0.00039 UJ
Aroclor-1221	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U
Aroclor-1232	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U
Aroclor-1242	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U
Aroclor-1248	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U
Aroclor-1254	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U
Aroclor-1260	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U
Polychlorinated biphenyls, Total	mg/L	0.0005	0.00039 U	0.00038 U	0.00039 U	0.00038 U	0.00038 U	0.00038 U	0.00039 U	0.00039 U

Appendix A-5.2
Table A-5.2 Notes

Summary of URS Groundwater Analytical Data
Comparison to Groundwater Component of the Groundwater Ingestion Exposure Route

Former Birmingham Steel Corporation
50-acre Joliet Works Facility
Joliet, Illinois

Notes:

FD: Field Duplicate
NV: No Value

Parameter Groups

PCBs: Polychlorinated Biphenyls
SVOCs: Semi-volatile Organic Compounds
VOCs: Volatile Organic Compounds

Qualifiers

J: The associated numerical value is an estimated quantity.

U: The chemical was analyzed for, but not detected. The associated numerical value is the reporting limit.

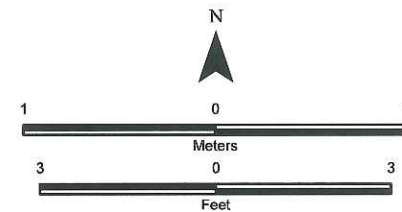
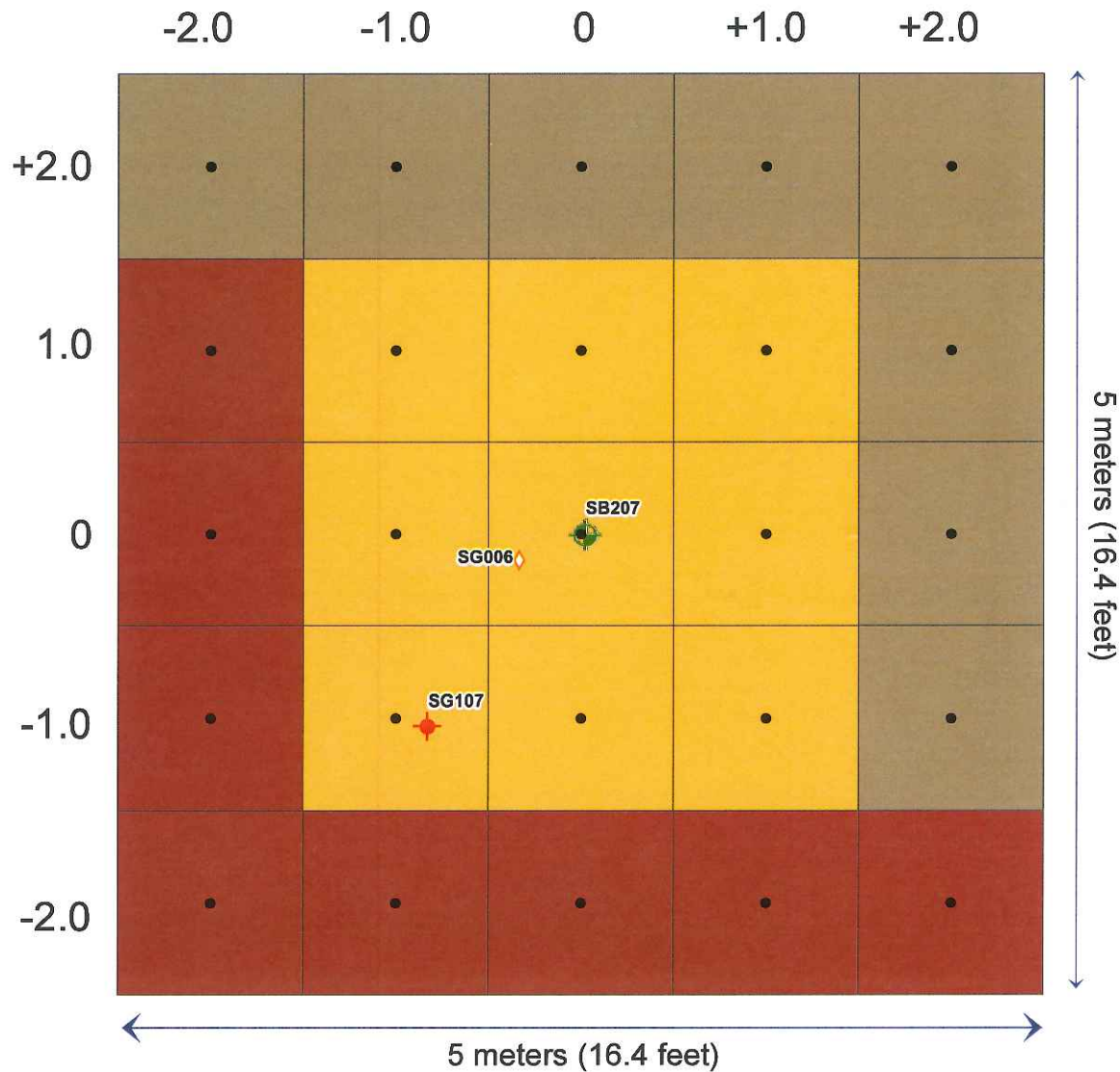
Bold typeface and no shading indicates a chemical was not detected, but its reporting limit exceeds the Tier 1 Groundwater Remediation Objective.

Yellow shading indicates detected concentration exceeds the Tier 1 Groundwater Remediation Objective.

Appendix B

PCB Sampling

Appendix B-1



Legend

- Initial Compositing Area (Sample 1)
- Subsequent Compositing Areas**
- Sample 2
- Sample 3

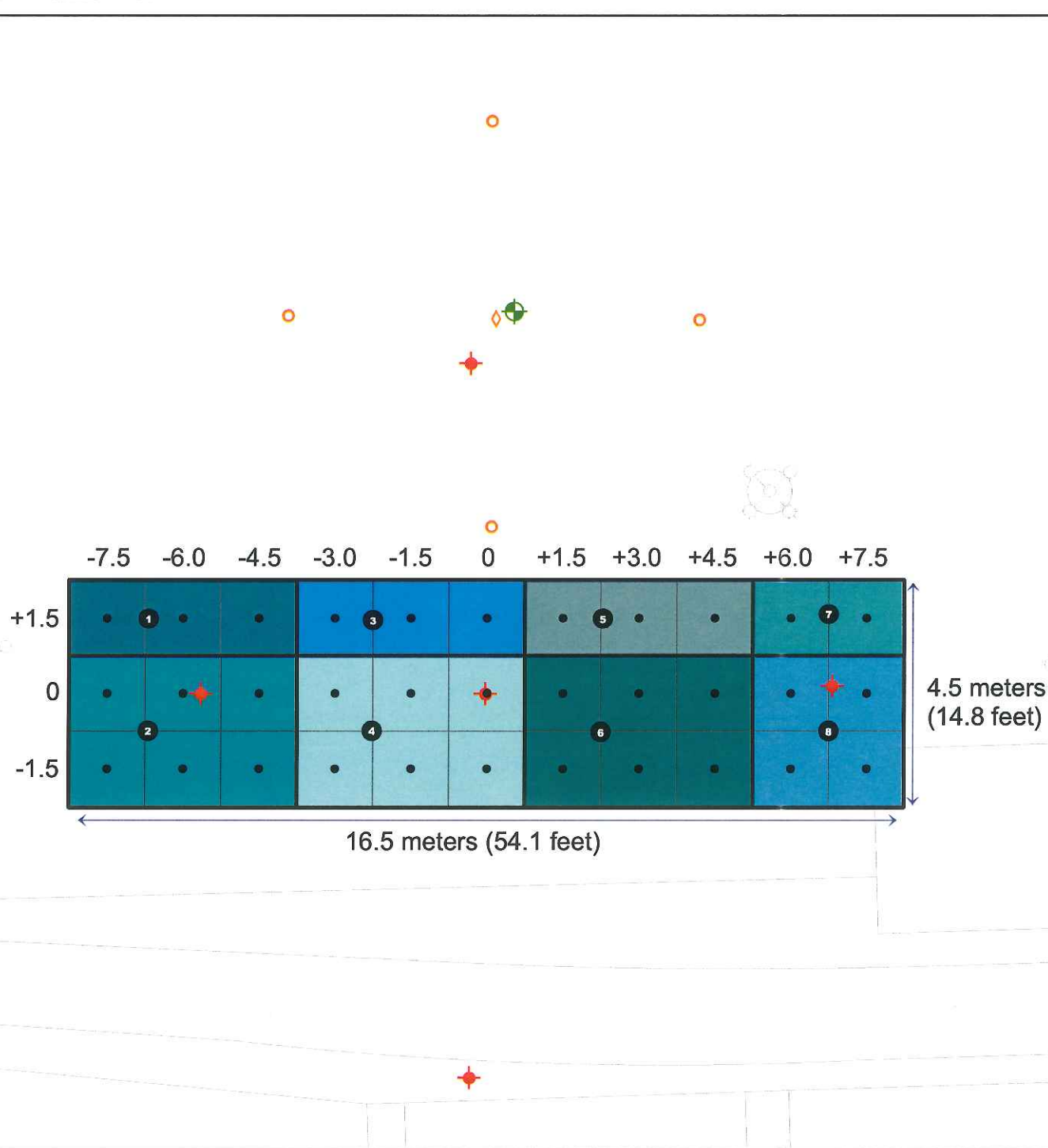
Proposed Number of Verification
 Samples: 3 Composite Samples

**LOCATIONS FOR VERIFICATION SAMPLING
 REMEDIATION AREA 8A**

**APPENDIX B-1
 FIGURE 1**

FORMER BIRMINGHAM STEEL CORPORATION
 FACILITY - 50-ACRE PARCEL
 927 COLLINS STREET, JOLIET, ILLINOIS

DATE: 2/27/2015
DRAWN BY: JO | CHECKED BY: PLH | JOB NO. 25369967



Legend



Compositing Area

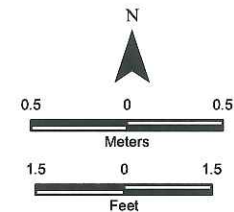
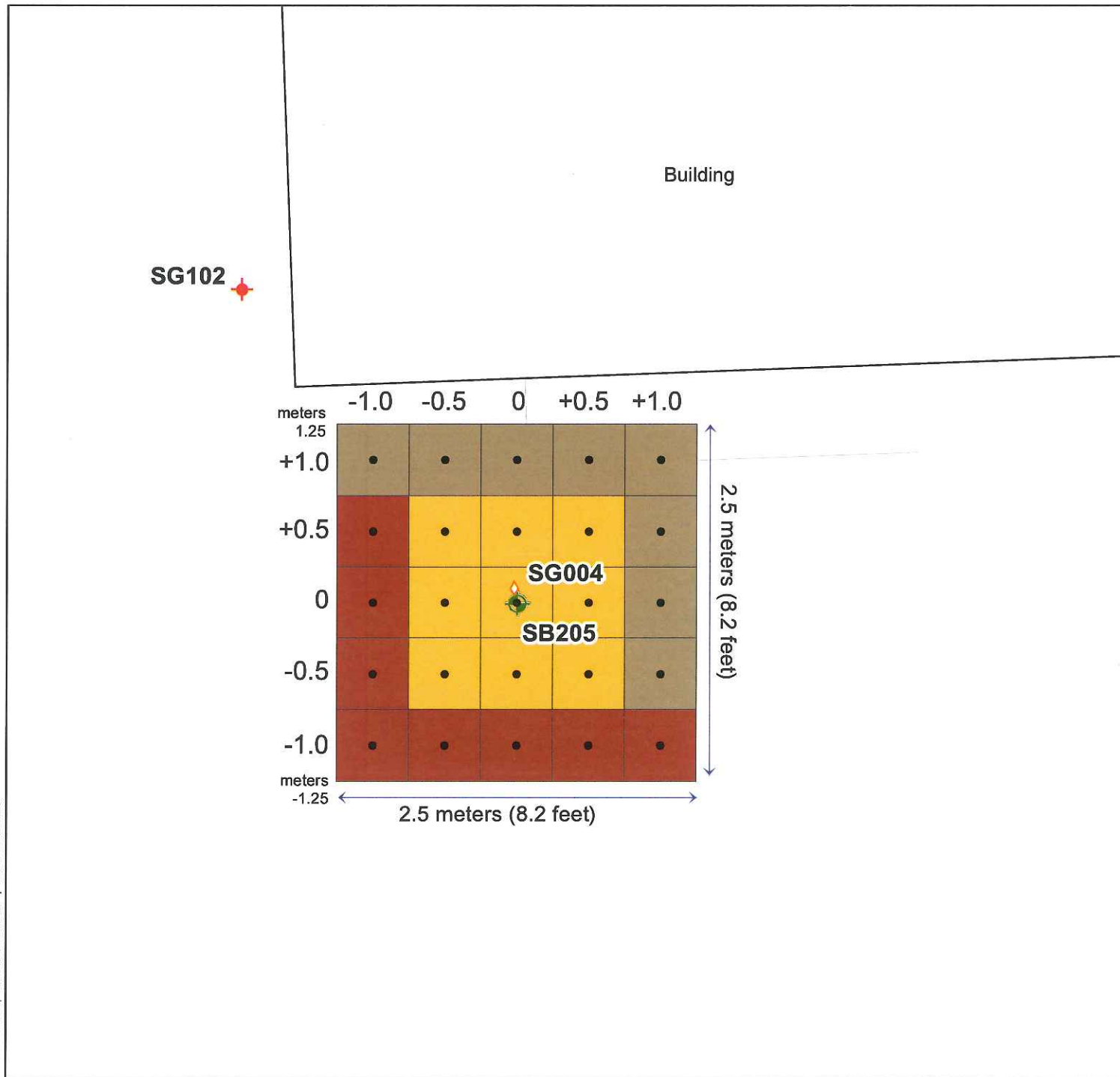
Proposed Number of Verification
Samples: 8 Composite Samples

LOCATIONS FOR VERIFICATION SAMPLING REMEDIATION AREA 8B

APPENDIX B-1 FIGURE 2

FORMER BIRMINGHAM STEEL CORPORATION
FACILITY - 50-ACRE PARCEL
927 COLLINS STREET, JOLIET, ILLINOIS





Legend

- Initial Compositing Area (Sample 1)
- Subsequent Compositing Areas**
 - Sample 2
 - Sample 3

Proposed Number of Verification
 Samples: 3 Composite Samples

LOCATIONS FOR VERIFICATION SAMPLING REMEDIATION AREA 9

APPENDIX B-1 FIGURE 3

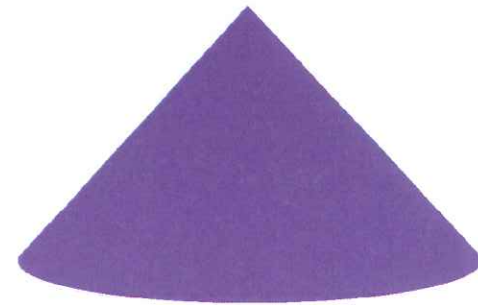
FORMER BIRMINGHAM STEEL CORPORATION
 FACILITY - 50-ACRE PARCEL
 927 COLLINS STREET, JOLIET, ILLINOIS

Appendix B-2

DATE: 3/4/2015
DRAWN BY: JO | CHECKED BY: PLH | JOB NO. 25369967
SOURCE: C:\DATA\PROJECT DATASETS\US STEEL\JOLIET\WYDSD\ACFE PARCEL\REMEDIATION\REPORT_01302015\APPE SAMPLING\EXAMPLES.MXD
FILENAME: C:\DELIVERABLES_LIBRARY\US STEEL\JOLIET\WYDSD\ACFE PARCEL\REMEDIATION\REPORT_01302015\APPE SAMPLING\EXAMPLES.MXD

1

Subpart R - Sampling a Conical Pile (§761.347)

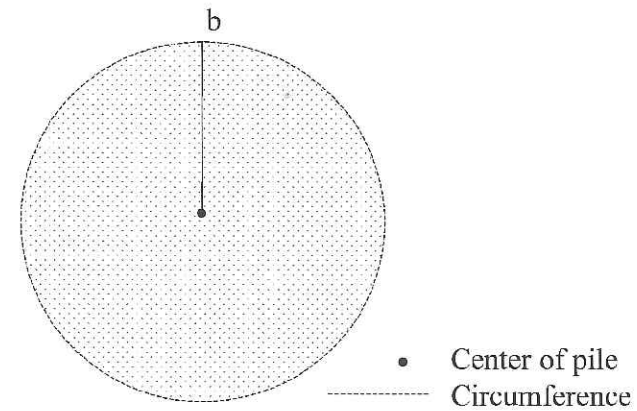


8/5/98 Preamble page 35412

Codified 63 FR 35470

2

Top View



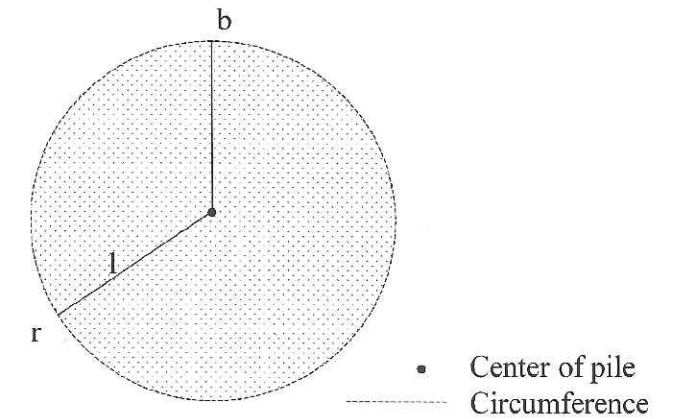
1. Mark center of pile using rod, stake, etc.
2. Run string from top of center marker to base (b)
3. Measure circumference (c) from base (b)

8/5/98 Preamble page 35412

Codified 63 FR 35470

3

Top View



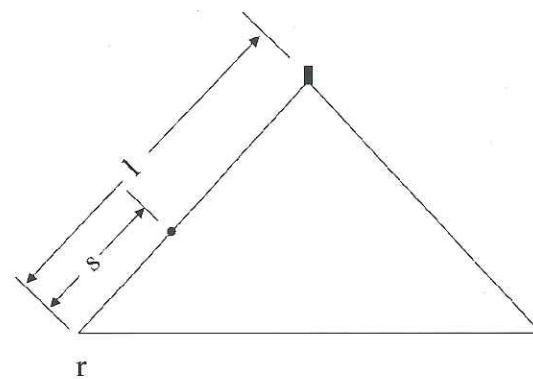
4. Find sampling radius (r) by multiplying circumference (c) by a random number
5. Run string from center marker to base at point (r)
6. Measure length (l) from center marker to base (r)

8/5/98 Preamble page 35412

Codified 63 FR 35470

4

Cross Section at r



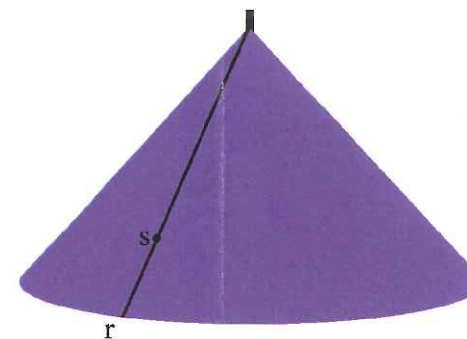
7. Find sampling length (s) by multiplying (l) by a random number
8. Starting from base (r), find point (s) on length (l)

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Codified 63 FR 35470

5

Three Dimensional View

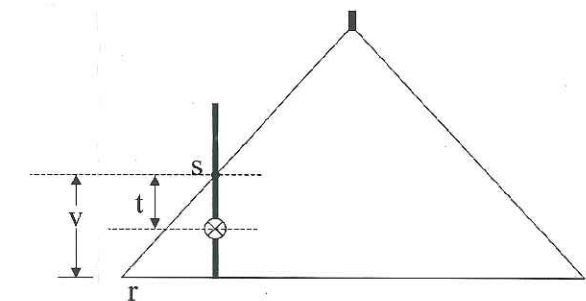


8/5/98 Preamble page 35412

Codified 63 FR 35470

6

Cross Section at r



Determine the vertical distance (v) by inserting a rod marked in cm
Find sampling depth (t) by multiplying (v) by a random number
Take sample at point (t)

8/5/98 Preamble page 35412

Codified 63 FR 35470

Source:
<http://www.epa.gov/epawaste/hazard/tsd/pubs/guidance.htm#subpartsampling>

SAMPLING PCB REMEDIATION WASTE FOR OFF-SITE DISPOSAL

APPENDIX B-2

FORMER BIRMINGHAM STEEL CORPORATION
FACILITY - 50-ACRE PARCEL
927 COLLINS STREET JOLIET, ILLINOIS

AECOM

Appendix C
Standard Operating Procedures

- F107 Test Pit and Excavation
- F206 Organic Vapors
- F302 Sample Handling
- F303 Use and Maintenance of Field Logbooks
- F304 QA QC Samples
- F501 Decontamination of Field Equipment and Materials
- F504 IDW Disposal
- F705 General Field Operations

TABLE OF CONTENTS

1.0	PURPOSE
2.0	SCOPE
3.0	DEFINITIONS
4.0	RESPONSIBILITIES
5.0	PROCEDURES
5.1	Test Pit Excavation
5.2	Health and Safety Considerations
5.3	Logging and Sampling
5.4	Backfilling
5.5	Test Pit Procedures
6.0	QUALITY ASSURANCE RECORDS
7.0	REFERENCES

ATTACHMENT A – OSHA – 29 CFR PART 1926 SAFETY AND HEALTH REGULATIONS
FOR CONSTRUCTION, SUBPART P – EXCAVATIONS
ATTACHMENT B – TEST PIT LOG

1.0 PURPOSE

The purpose of this procedure is to provide general reference information and technical guidance on the excavation of exploratory test pits and test trenches at the U.S. Steel (USS) Gary Works Facility.

2.0 SCOPE

These procedures provide overall technical guidance and may be modified by site-specific requirements for field exploratory trenches and test pits. Conditions which would make trench excavation difficult (such as a shallow water table), dangerous (presence of explosive materials or underground utilities), or likely to cause environmental problems (such as potential rupture of buried containerized wastes) will require modifications to the procedures presented herein and may prevent implementation of the exploratory excavation program. Consequently, the techniques described herein are most applicable in areas of low apparent contamination and where potentially explosive materials are not expected to be present.

3.0 DEFINITIONS

Trench – Trench means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less (measured at the bottom of the excavation), the excavation is also considered to be a trench (definition from *Federal Register*, Vol. 54 No. 209, August 9, 1994, 29 CFR Part 1926, *Safety and Health Regulations for Construction*, Subpart P -- Excavations) (see Attachment A).

Test Pit – A test pit is a small excavation made below ground surface to characterize soil type and quality as well as determine the types of wastes buried. In general, a test pit is dug using a backhoe with dimensions measured as follows:

- Width - Typically one to three backhoe buckets wide (two to ten feet)
- Length - Typically five to ten feet long (at the base)
- Depth - Typically to the top of the water table, one to two feet below the base of the fill material, or until the trench becomes unstable and begins caving

4.0 RESPONSIBILITIES

Project Manager – It is the responsibility of the Project Manager to ensure that field personnel responsible for trench and test pit excavations are familiar with these procedures. It also is the

responsibility of the Project Manager to verify that all appropriate documents (i.e., Test Pit Logs) have been completely and correctly filled out by the field inspector.

Field Team Leader – The Field Team Leader is responsible for the overall supervision of all test pit and trenching activities, and for ensuring that each test pit is properly and completely logged by the field inspector. It also is the responsibility of the Field Team Leader to ensure that all field inspectors have been briefed on these procedures.

Field Inspector – The Field Inspector is responsible for the direct oversight of test pit and trenching activities. It is the Field Inspector's responsibility to log each test pit, document subsurface conditions, complete appropriate forms, and in some cases act as the Excavation Competent Person – that is, identify excavation hazards and ensure the use of adequate protective systems, work methods, and personal protective equipment on site in accordance with excavation regulations and best management practices – but only if the Field Inspector has been certified as an Excavation Competent Person. (The excavation contractor typically provides the Excavation Competent Person at test pit and trench excavation work sites.)

5.0 PROCEDURES

The procedures for test pit sizes, health and safety considerations, sampling, and backfilling are discussed in the following sections. Regulations for trench excavation, including trench sizes, are given in the August 9, 1994 edition of the *Federal Register*, 29 CFR Part 1926, *Safety and Health Regulations for Construction*, Subpart P -- Excavations (Attachment A).

5.1 Test Pit and Test Trench Excavation

Test pits and trenches permit detailed exploration of the nature and contamination of in-situ materials, as well as the characteristics and stratification of near surface materials. The size of the excavation will depend on:

- Purpose and intent of the exploration.
- Space limitations imposed by site conditions (i.e., proximity to buildings, utilities, etc.)
- Contaminants present and the potential for release to the environment.
- Stability of the materials being excavated.
- Capabilities and limitations of the excavating equipment.

Standard equipment (i.e., backhoe) is readily available to excavate to depths of up to about 15 feet. However, larger and deeper excavations may be required. At times, standard equipment can be used to excavate deeper than their nominal limits by stepping or benching the excavation.

5.2 Health and Safety Considerations

All test pit and trench excavation activities should be conducted under the guidance of a project specific Health and Safety Plan.

The Health and Safety Plan should specify precautions to be observed relative to possible chemical or physical hazards associated with these operations. Chemical hazards may occur from direct exposure to excavated wastes or inhalation of volatilized materials. Physical hazards include the possible collapse of the trench or test pit, possible injury through violent contact with excavation equipment, or explosion or other forceful reaction upon contact with utilities, exposed drums, or other wastes. Respiratory and personal protective equipment to be worn by on-site personnel involved in excavation operations to mitigate chemical and physical hazards also should be specified in the Health and Safety Plan.

At locations where access is not restricted, a safety zone should be established around the excavation. Additionally, personnel should not enter the excavation without appropriate written health and safety procedures approved by the Excavation Competent Person. Prior written approval and procedures as specified in the Sampling and Analysis Plan and the project Health and Safety Plan are required if entry into the excavation is to be considered. Additionally, a Site Health and Safety Officer familiar with excavations should be on site to direct the entry procedures. Most excavations would be considered as confined space entry situations, requiring certified confined space entry personnel.

5.3 Logging and Sampling

Test pits and/or trenches should be logged and sampled by the Field Inspector. Soils should be classified and described in accordance with ASTM D-2487-92 and the procedures given in Standard Operating Procedure (SOP) F101. Test Pit Logs (Attachment B) should be legibly completed for all test pits. Samples should only be collected from material in the equipment bucket, or from the pile of excavated materials. The excavation should not be entered for the purpose of collecting samples without appropriate written health and safety procedures approved by the Excavation Competent Person.

5.4 Backfilling

Backfilling of trenches and test pits is a normally accepted practice to reduce immediate site hazards and minimize the potential for rainwater accumulation and subsequent contaminant migration.

After inspection and completion of the appropriate test pit logs, backfill material should be returned to the pit under the oversight of the field inspector. Any hazardous and/or waste materials which are not returned to the excavation as backfill must be collected and properly disposed. Where it is

safe to do so, the backhoe bucket should be used to compact each one to two-foot layer of backfill as it is placed to reduce future settling.

5.5 Test Pit Procedures

The following procedures apply to the excavation and backfilling of a typical test pit. Note that if a subcontractor is procured to perform the test pit operations, the subcontractor must provide an equipment operator and a supervisor:

- The positions of the test pits should be located in the field by the Field Team Leader.
- Utility clearance should be obtained for all test pit locations prior to excavation.
- Excavation equipment should be thoroughly decontaminated as necessary, either when moving from one solid waste management unit/area of concern to another, or prior to and after each test pit excavation (see SOP 502).
- A safety zone should be established around the test pit location prior to initiation of excavation activities.
- Excavation should commence by removing lifts of no more than approximately 6 to 12 inches of soil.
- The Field Inspector should log the test pit soils and record observations on a Test Pit Log. Additionally, the test pit cross-section shall be sketched on the Test Pit Log with notable features identified.
- If applicable, soil or waste samples should be collected either from the backhoe bucket or from the pile of excavated materials following SOP 105.
- Test pit depths (and water levels) may be measured using an engineer's rule (six foot) or a weighted measuring tape. Depths should be measured from the ground surface.
- Upon completion, test pits should be immediately backfilled as described in Section 5.4.
- The test pit locations should be surveyed by a registered land surveyor, surveyed with a GPS device, or measured and referenced to nearby permanent site structures (i.e., buildings, curbs, fences, etc.)

6.0 QUALITY ASSURANCE RECORDS

The Quality Assurance Records that should be prepared include Test Pit Logs and notations in the Field Logbook.

7.0 REFERENCES

Occupational Safety & Health Administration, *Safety and Health Regulations for Construction, 29 CFR Part 1926, Subpart P - Excavations*, 9 August 1994, <<http://www.osha.gov/pls/oshaweb/owastand>>.

Regulations (Standards - 29 CFR)

1926 Subpart P - Excavations

1926.650 - Scope, application, and definitions applicable to this subpart.

1926.651 - Specific Excavation Requirements.

1926.652 - Requirements for protective systems.

1926 Subpart P App A - Soil Classification

1926 Subpart P App B - Sloping and Benching

1926 Subpart P App C - Timber Shoring for Trenches

1926 Subpart P App D - Aluminum Hydraulic Shoring for Trenches

1926 Subpart P App E - Alternatives to Timber Shoring

1926 Subpart P App F - Selection of Protective Systems

AUTHORITY: Sec. 107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8734), 8-76 (41 FR 23059), 9-83 (48 FR 35736), or 1-90 (55 FR 9033), as applicable.

Section 1926.651 also issued under 29 CFR Part 1911.

SOURCE: 54 FR 45959, Oct. 31, 1989, unless otherwise noted.

[59 FR 40730, Aug. 9, 1994]

1926.650(a)

Scope and application. This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

1926.650(b)

Definitions applicable to this subpart.

"Accepted engineering practices" means those requirements which are compatible with standards of practice required by a registered professional engineer.

"Aluminum Hydraulic Shoring" means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (wales). Such system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

ATTACHMENT A

OSHA - 29 CFR PART 1926 SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION, SUBPART P - EXCAVATIONS

"Bell-bottom pier hole" means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

"Benching (Benching system)" means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

"Cave-in" means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

"Competent person" means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

"Cross braces" mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

"Excavation" means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

"Faces" or "sides" means the vertical or inclined earth surfaces formed as a result of excavation work.

"Failure" means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

"Hazardous atmosphere" means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

"Kickout" means the accidental release or failure of a cross brace.

"Protective system" means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

"Ramp" means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

"Registered Professional Engineer" means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

"Shooting" means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

"Shield (Shield system)" means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

"Shoring (Shoring system)" means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

"Sides". See "Faces."

"Sloping (Sloping system)" means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

"Stable rock" means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

"Structural ramp" means a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

"Support system" means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

"Tabulated data" means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

"Trench (Trench excavation)" means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

"Trench box." See "Shield."

"Trench shield." See "Shield."

"Uprights" means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

"Wales" means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

1926.651(a)

Surface encumbrances. All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

1926.651(b)

Underground installations.

1926.651(b)(1)

The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

1926.651(b)(2)

Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

..1926.651(b)(3)

1926.651(b)(3)

When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.

1926.651(b)(4)

While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

1926.651(c)

Access and egress -

1926.651(c)(1)

Structural ramps.

1926.651(c)(1)(i)

Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

1926.651(c)(1)(ii)

Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

1926.651(c)(1)(iii)

Structural members used for ramps and runways shall be of uniform thickness.

1926.651(c)(1)(iv)

Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

..1926.651(c)(1)(v)

1926.651(c)(1)(v)

Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

1926.651(c)(2)

Means of egress from trench excavations. A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

1926.651(d)

Exposure to vehicular traffic. Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

1926.651(e)

Exposure to falling loads. No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.

..1926.651(f)

1926.651(f)

Warning system for mobile equipment. When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

1926.651(g)

Hazardous atmospheres -

1926.651(g)(1)

Testing and controls. In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50 - 1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

1926.651(g)(1)(i)

Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

1926.651(g)(1)(ii)

Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

1926.651(g)(1)(iii)

Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

..1926.651(g)(1)(iv)

1926.651(g)(1)(iv)

When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

1926.651(g)(2)

Emergency rescue equipment.

1926.651(g)(2)(i)

Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

1926.651(g)(2)(ii)

Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

1926.651(h)

Protection from hazards associated with water accumulation.

1926.651(h)(1)

Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

..1926.651(h)(2)

1926.651(h)(2)

Sidewalks, pavements and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

1926.651(i)

Protection of employees from loose rock or soil.

1926.651(i)(1)

Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary from the face to stop and contain falling material; or other means that provide equivalent protection.

..1926.651(i)(2)

1926.651(i)(2)

Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

1926.651(k)

Inspections.

1926.651(k)(1)

Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

1926.651(k)(2)

Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

1926.651(l)

If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

1926.651(h)(3)

If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (b)(1) and (h)(2) of this section.

1926.651(i)

Stability of adjacent structures.

1926.651(i)(1)

Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

1926.651(i)(2)

Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

1926.651(i)(2)(i)

A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

1926.651(i)(2)(ii)

The excavation is in stable rock; or

..1926.651(i)(2)(iii)

1926.651(i)(2)(iii)

A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or

1926.651(i)(2)(iv)

A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

1926.651(i)(3)

Fall protection.

1926.651(j)(1)

Walkways shall be provided where employees or equipment are required or permitted to cross over excavations. Guardrails which comply with 1926.502(b) shall be provided where walkways are 6 feet (1.8 m) or more above lower levels.

[59 FR 40730, Aug 9, 1994]

1926.652(a)

Protection of employees in excavations.

1926.652(a)(1)

Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

1926.652(a)(1)(i)

Excavations are made entirely in stable rock; or

1926.652(a)(1)(ii)

Excavations are less than 5 feet (1.52 m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

1926.652(a)(2)

Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

..1926.652(b)

1926.652(b)

Design of sloping and benching systems. The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3); or, in the alternative, paragraph (b)(4), as follows:

1926.652(b)(1)

Option (1) - Allowable configurations and slopes.

1926.652(b)(1)(i)

Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

1926.652(b)(1)(ii)

Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

1926.652(b)(2)

Option (2) - Determination of slopes and configurations using Appendices A and B. Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.

1926.652(b)(3)

Option (3) - Designs using other tabulated data.

1926.652(b)(3)(i)

Designs of sloping or benching systems shall be selected from and in accordance with tabulated data, such as tables and charts.

1926.652(b)(3)(ii)

The tabulated data shall be in written form and shall include all of the following:

..1926.652(b)(3)(ii)(A)

1926.652(b)(3)(ii)(A)

Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

1926.652(b)(3)(ii)(B)

Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

1926.652(b)(3)(ii)(C)

Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

1926.652(b)(3)(iii)

At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

1926.652(b)(4)

Option (4) - Design by a registered professional engineer.

1926.652(b)(4)(i)

Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

1926.652(b)(4)(ii)

Designs shall be in written form and shall include at least the following:

1926.652(b)(4)(ii)(A)

The magnitude of the slopes that were determined to be safe for the particular project;

..1926.652(b)(4)(ii)(B)

1926.652(b)(4)(ii)(B)

The configurations that were determined to be safe for the particular project;

1926.652(b)(4)(ii)(C)

The identity of the registered professional engineer approving the design.

1926.652(b)(4)(iii)

At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

1926.652(c)(3)(iii)

At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

1926.652(c)(4)

Option (4) - Design by a registered professional engineer.

1926.652(c)(4)(i)

Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

1926.652(c)(4)(ii)

Designs shall be in written form and shall include the following:

1926.652(c)(4)(ii)(A)

A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

1926.652(c)(4)(ii)(B)

The identity of the registered professional engineer approving the design.

..1926.652(c)(4)(iii)

1926.652(c)(4)(iii)

At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

1926.652(d)

Materials and equipment.

1926.652(d)(1)

Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

1926.652(d)(2)

Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

1926.652(d)(3)

When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

1926.652(e)

Installation and removal of support -

1926.652(c)

Design of support systems, shield systems, and other protective systems. Designs of support systems, shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

1926.652(c)(1)

Option (1) - Designs using appendices A, C and D. Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

..1926.652(c)(2)

1926.652(c)(2)

Option (2) - Designs Using Manufacturer's Tabulated Data.

1926.652(c)(2)(i)

Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

1926.652(c)(2)(ii)

Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

1926.652(c)(2)(iii)

Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

1926.652(c)(3)

Option (3) - Designs using other tabulated data.

1926.652(c)(3)(i)

Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

1926.652(c)(3)(ii)

The tabulated data shall be in written form and include all of the following:

1926.652(c)(3)(ii)(A)

Identification of the parameters that affect the selection of a protective system drawn from such data;

..1926.652(c)(3)(ii)(B)

1926.652(c)(3)(ii)(B)

Identification of the limits of use of the data;

1926.652(c)(3)(ii)(C)

1926.652(e)(1)

General.

1926.652(e)(1)(i)

Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

..1926.652(e)(1)(ii)

1926.652(e)(1)(ii)

Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

1926.652(e)(1)(iii)

Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

1926.652(e)(1)(iv)

Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

1926.652(e)(1)(v)

Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

1926.652(e)(1)(vi)

Backfilling shall progress together with the removal of support systems from excavations.

..1926.652(e)(2)

1926.652(e)(2)

Additional requirements for support systems for trench excavations.

1926.652(e)(2)(i)

Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

1926.652(e)(2)(ii)

Installation of a support system shall be closely coordinated with the excavation of trenches.

1926.652(f)

Sloping and benching systems. Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

1926.652(g)

Shield systems -

1926.652(g)(1)

General.

1926.652(g)(1)(i)

Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

1926.652(g)(1)(ii)

Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

1926.652(g)(1)(iii)

Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

1926.652(g)(1)(iv)

Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

1926.652(g)(2)

Additional requirement for shield systems used in trench excavations. Excavations of earth material to a level not greater than 2 feet (61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

(a) Scope and application - (1) Scope. This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) Application. This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in 1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in 1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) Definitions. The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System; The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS-121.

"Cemented soil" means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

into the excavation on a slope of four horizontal to one vertical (4R:1V)

or greater; or

(v) The material is subject to other factors that would require it to be classified as a less stable material.

"Type B" means:

(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.

(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.

(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

(v) Dry rock that is not stable; or

(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4R:1V), but only if the material would otherwise be classified as Type B.

"Type C" means:

(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48

kPa) or less; or

(ii) Granular soils including gravel, sand, and loamy sand; or

(iii) Submerged soil or soil from which water is freely seeping; or

(iv) Submerged rock that is not stable; or

(v) Material in a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4R:1V) or steeper.

"Unconfined compressive strength" means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

"Wet soil" means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit

cohesive properties when moist will lose those cohesive properties when wet.

(c) Requirements - (1) Classification of soil and rock deposits. Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) Basis of classification. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods

"Cohesive soil" means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical side slopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

"Dry soil" means soil that does not exhibit visible signs of moisture content.

"Fissured" means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

"Granular soil" means gravel, sand, or silt (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

"Layered system" means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

"Moist soil" means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains

cohesive material will exhibit signs of cohesion between particles.

"Plastic" means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

"Saturated soil" means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer

or shear vane.

"Soil classification system" means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the characteristics of the

deposits and the environmental conditions of exposure.

"Stable rock" means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

"Submerged soil" means soil which is underwater or is free seeping.

"Type A" means cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche

and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or

(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or

(iv) The soil is part of a sloped, layered system where the layers dip

of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) Visual and manual analyses. The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) Layered systems. In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) Reclassification. If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) Acceptable visual and manual tests. - (1) Visual tests. Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) Manual tests. Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(f) Plasticity. Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.

(g) Dry strength. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) Thumb penetration. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488 - "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) Other strength tests. Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shear vane.

(v) Drying test. The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

(a) *Scope and application.* This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in § 1926.652(b)(2).

(b) *Definitions.*

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and raveling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements -- (1) Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart F of part 1926.

(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least 1/4 horizontal to one vertical (1/4H:1V) less steep than the maximum allowable slope.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be

reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with § 1926.651(f).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

TABLE B-1
MAXIMUM ALLOWABLE SLOPES

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V)(1) FOR EXCAVATIONS LESS THAN 20 FEET DEEP(2)
STABLE ROCK	VERTICAL (90°)
TYPE A (2)	3/4:1 (53°)
TYPE B	1:1 (45°)
TYPE C	1 1/2:1 (34°)

Footnote(1) Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.

Footnote(2) A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).

Footnote(3) Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

Figure B-1

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

B-1.1 Excavations made in Type A soil.

1. All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of 3/4:1.



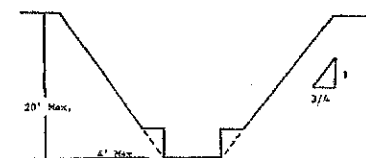
SIMPLE SLOPE -- GENERAL

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of 1/2:1.

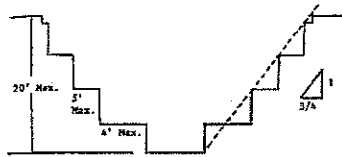


SIMPLE SLOPE -- SHORT TERM

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 3/4 to 1 and maximum bench dimensions as follows:

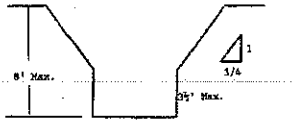


SIMPLE BENCH



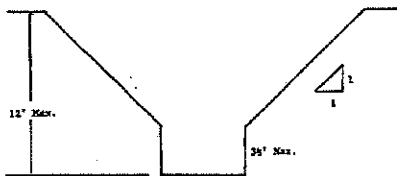
MULTIPLE BENCH

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3 1/4 feet.

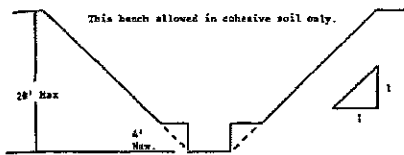


UNSUPPORTED VERTICALLY SIDED LOWER PORTION -- MAXIMUM 8 FEET IN DEPTH)

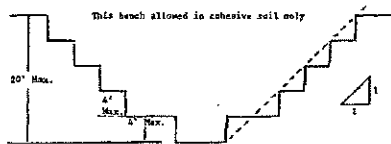
All excavations more than 8 feet but not more than 12 feet in depth with unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3 1/4 feet.



UNSUPPORTED VERTICALLY SIDED LOWER PORTION -- MAXIMUM 12 FEET IN DEPTH)

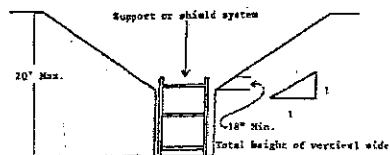


SINGLE BENCH



MULTIPLE BENCH

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

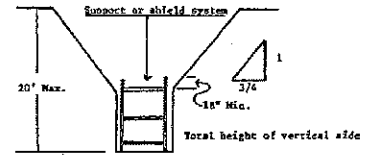


VERTICALLY SIDED LOWER PORTION

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.3 Excavations Made in Type C Soil

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of 3/4:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

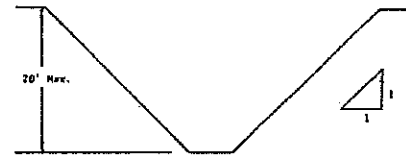


SUPPORTED OR SHIELDED VERTICALLY SIDED LOWER PORTION

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

B-1.2 Excavations Made in Type B Soil

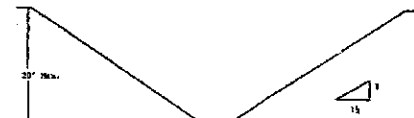
1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.



SIMPLE SLOPE

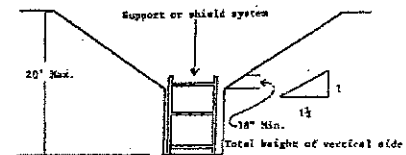
2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1 1/2:1.



SIMPLE SLOPE

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1 1/2:1.

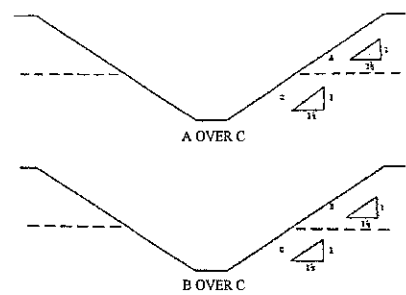
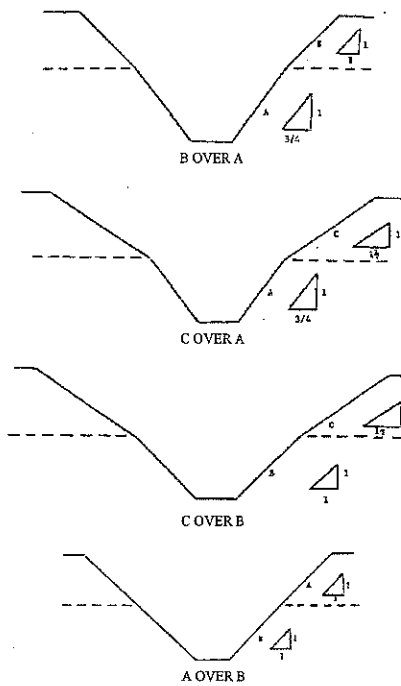


VERTICAL SIDED LOWER PORTION

3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.4 Excavations Made in Layered Soils

1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



2. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

(a) Scope. This appendix contains information that can be used when timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with 1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in 1926.652(b) and 1926.652(c).

(b) Soil Classification. In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) Presentation of Information. Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2 and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.

(d) Basis and limitations of the data. - (1) Dimensions of timber members. (i) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under 1926.652(c)(3), and are referred to The Corps of engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) Limitation of application. (i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with 1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) Use of Tables. The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces are known, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) Examples to Illustrate the Use of Tables C-1.1 through C-1.3.

(1) Example 1.

A trench dug in Type A soil is 13 feet deep and five feet wide.

From Table C-1.1, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4X4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3X8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4X6 crossbraces at eight feet horizontally and four feet vertically.

Space 8X8 wales at four feet vertically.

Space 2X6 uprights at four feet horizontally.

Arrangement #3

Space 6X6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8X10 wales at four feet vertically.

Space 2X6 uprights at five feet horizontally.

Arrangement #4

Space 6X6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10X10 wales at four feet vertically.

Space 3X8 uprights at six feet horizontally.

(2) Example 2.

A trench dug in Type B soil is 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1

Space 6X6 crossbraces at six feet horizontally and five feet vertically.

Space 8X8 wales at five feet vertically.

Space 2X6 uprights at two feet horizontally.

Arrangement #2

Space 6X8 crossbraces at eight feet horizontally and five feet vertically.

Space 10X10 wales at five feet vertically.

Space 2X6 uprights at two feet horizontally.

Arrangement #3

Space 8X8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10X12 wales at five feet vertically.

Space 2X6 uprights at two feet vertically.

(3) Example 3.

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8X8 crossbraces at six feet horizontally and five feet vertically.

Space 10X12 wales at five feet vertically.

Position 2X6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8X10 crossbraces at eight feet horizontally and five feet vertically.

Space 12X12 wales at five feet vertically.

Position 2X6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) Example 4.

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8X10 crossbraces at six feet horizontally and five feet vertically.

Space 12X12 wales at five feet vertically.

Use 3X6 tight sheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) Notes for all Tables.

1. Member sizes at spacings other than indicated are to be determined as specified in 1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the low of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P(a) = 25 X H + 72 psf (2 ft Surcharge)

		SIZE (ACTUAL) AND SPACING OF MEMBERS **					
DEPTH OF		CROSS BRACES					
TRENCH/SPACING		WIDTH OF TRENCH (FEET)					VERT. SPACING
(FEET)	(FEET)	UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15	(FEET)
5	UP TO 5	4X4	4X6	4X6	6X6	6X6	4
TO 10	UP TO 8	4X4	4X4	4X6	6X6	6X6	4
10	UP TO 10	4X6	4X6	4X6	6X6	6X6	4
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4
	UP TO						

10	UP TO 8	4X6	4X6	6X6	6X6	6X6	4
TO 15	UP TO 10	6X6	6X6	6X6	6X8	6X8	4
15	UP TO 12	6X6	6X6	6X6	6X8	6X8	4
	UP TO 6	6X6	6X6	6X6	6X8	6X8	4
15	UP TO 8	6X6	6X6	6X6	6X8	6X8	4
TO 20	UP TO 10	8X8	8X8	8X8	8X8	8X10	4
20	UP TO 12	8X8	8X8	8X8	8X8	8X10	4
OVER 20	SEE NOTE 1						

TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P(a) = 25 X H + 72 psf (2 ft Surcharge)

[Continued]

DEPTH OF TRENCH	SIZE (ACTUAL) AND SPACING OF MEMBERS **	
	WALES	UPRIGHTS
TRENCH SPACING	VERT. SPACING	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)

(FEET)	SIZE		CLOSE	4	5	6	8
	(IN)	(FEET)					
5	Not Req'd	---				2X6	
TO	Not Req'd	---					2X8
10	8X8	4			2X6		
	8X8	4			2X6		
10	Not Req'd	---				3X8	
TO	8X8	4		2X6			
15	8X10	4			2X6		
	10X10	4				3X8	
15	8X8	4	3X6				
	8X8	4	3X6				
TO	8X10	4	3X6				
20	10X10	4	3X6				
OVER	SEE NOTE 1						

15	10	8X8	8X8	8X8	8X8	8X10	5
	See Note 1						
15	UP TO 6	6X8	6X8	6X8	8X8	8X9	5
TO	UP TO 8	8X8	8X8	8X8	8X8	8X10	5
20	UP TO 10	8X10	8X10	8X10	8X10	10X10	5
20	See Note 1						
OVER 20	SEE NOTE 1						

TABLE C-1.2
TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *
SOIL TYPE B P(a) = 45 X H + 72 psf (2 ft Surcharge)
[Continued]

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **						
	WALES		UPRIGHTS				
	SIZE	VERT. SPACING	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
	(IN)	(FEET)	CLOSE	2	3		

20

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-1.2
TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *
SOIL TYPE B P(a) = 45 X H + 72 psf (2 ft Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **						
	CROSS BRACES		WIDTH OF TRENCH (FEET)				
	HORIZ. SPACING		VERT. SPACING				
	(FEET)		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15
5	UP TO 6	4X6	4X6	6X6	6X6	6X6	5
TO	UP TO 8	6X6	6X6	6X6	6X8	6X8	5
10	UP TO 10	6X6	6X6	6X6	6X8	6X8	5
	See Note 1						
10	UP TO 6	6X6	6X6	6X6	6X8	6X8	5
TO	UP TO 8	6X8	6X8	6X8	8X8	8X8	5
TO	UP TO						

5	6X8	5			2X6		
TO	8X10	5			2X6		
10	10X10	5			2X6		
10	8X8	5		2X6			
TO	10X10	5		2X6			
TO	10X12	5		2X6			
15							
15	8X10	5	3X6				
TO	10X12	5	3X6				
TO	12X12	5	3X6				
20							
OVER 20	SEE NOTE 1						

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for

wood.

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P(a) = 80 \times H + 72$ psf (2 ft Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **					
	CROSS BRACES					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15 (FEET)
5	UP TO 6	6X8	6X8	6X8	6X8	6X8
TO	UP TO 8	8X8	8X8	8X8	8X8	8X10
10	UP TO 10	8X10	8X10	8X10	8X10	10X10
	See Note 1					
10	UP TO 6	8X8	8X8	8X8	8X8	8X10
TO	UP TO 8	8X10	8X10	8X10	8X10	10X10
	See Note 1					
15	See Note 1					

	12X12	5	2X6			
10	10X12	5	2X6			
TO	12X12	5	2X6			
15						
	12X12	5	3X6			
15						
TO						
20						
OVER 20	SEE NOTE 1					

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A $P(a) = 25 \times H + 72$ psf (2 ft Surcharge)

	UP TO 6	8X10	8X10	8X10	8X10	10X10	5
15	See Note 1						
TO	See Note 1						
20	See Note 1						
OVER 20	SEE NOTE 1						

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P(a) = 80 \times H + 72$ psf (2 ft Surcharge)

[Continued]

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **					
	WALES		UPRIGHTS			
	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)			
			CLOSE			
5	8X10	5	2X6			
TO	10X12	5	2X6			
10						

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **					
	CROSS BRACES					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15 (FEET)
5	UP TO 6	4X4	4X4	4X4	4X4	4X6
TO	UP TO 8	4X4	4X4	4X4	4X6	4X6
10	UP TO 10	4X6	4X6	4X6	6X6	6X6
	UP TO 12	4X6	4X6	4X6	6X6	6X6
10	UP TO 6	4X4	4X4	4X4	6X6	6X6
TO	UP TO 8	4X6	4X6	4X6	6X6	6X6
15	UP TO 10	6X6	6X6	6X6	6X6	6X6
	UP TO 12	6X6	6X6	6X6	6X6	6X6
15	UP TO 6	6X6	6X6	6X6	6X6	6X6
TO	UP TO 8	6X6	6X6	6X6	6X6	6X6

TO	UP TO						
	10	6X6	6X6	6X6	6X6	6X8	4
20	UP TO						
	12	6X6	6X6	6X6	6X8	6X8	4
OVER	SEE NOTE 1						
20							

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A $P(a) = 25 \times H + 72$ psf (2 ft Surcharge)

(Continued)

SIZE (S4S) AND SPACING OF MEMBERS **							
DEPTH OF TRENCH (FEET)	WALES		UPRIGHTS				
	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
			CLOSE	4	5	6	8
5	Not Req'd	Not Req'd				4X6	
TO	Not Req'd	Not Req'd					4X8
10	8X8	4			4X6		
	8X8	4				4X6	
	Not	Not					

	Req'd	Req'd				4X10	
10	6X8	4		4X6			
TO	8X8	4			4X8		
15	8X10	4		4X6		4X10	
	6X8	4	3X6				
15	8X8	4	3X6	4X12			
TO	8X10	4	3X6				
20	8X12	4	3X6	4X12			
OVER	SEE NOTE 1						
20							

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B $P(a) = 45 \times H + 72$ psf (2 ft Surcharge)

SIZE (S4S) AND SPACING OF MEMBERS **							
DEPTH OF TRENCH (FEET)	WALES		UPRIGHTS				
	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
			CLOSE	2	3		
5	6X8	5			3X12 4X8		4X12
TO	8X8	5		3X6		4X8	
10	8X10	5			4X8		
	8X8	5	3X6	4X10			
10	10X10	5	3X6	4X10			
TO							

TRENCH (FEET)	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15	
5	UP TO 6	4X6	4X6	4X6	6X6	6X6	5
TO	UP TO 8	4X6	4X6	6X6	6X6	6X6	5
10	UP TO 10	4X6	4X6	6X6	6X6	6X8	5
	See Note 1						
10	UP TO 6	6X6	6X6	6X6	6X8	6X8	5
TO	UP TO 8	6X8	6X8	6X8	8X8	8X8	5
15	UP TO 10	6X8	6X8	8X8	8X8	8X8	5
	See Note 1						
15	UP TO 6	6X8	6X8	6X8	6X8	8X8	5
TO	UP TO 8	6X8	6X8	6X8	8X8	8X8	5
20	UP TO 10	8X8	8X8	8X8	8X8	8X8	5
	See						

Note 1						
OVER	SEE NOTE 1					
20						

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B $P(a) = 45 \times H + 72$ psf (2 ft Surcharge)

(Continued)

SIZE (S4S) AND SPACING OF MEMBERS **							
DEPTH OF TRENCH (FEET)	WALES		UPRIGHTS				
	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
			CLOSE	2	3		
5	6X8	5			3X12 4X8		4X12
TO	8X8	5		3X6		4X8	
10	8X10	5			4X8		
	8X8	5	3X6	4X10			
10	10X10	5	3X6	4X10			
TO							

15	10X12	5	3X6	4X10					
15	8X10	5	4X6						
10	10X12	5	4X6						
20	12X12	5	4X6						
OVER 20	SEE NOTE 1								

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
 ** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P(a) = 80 \times H + 72$ psf (2 ft Surcharge)

	SIZE {S4S} AND SPACING OF MEMBERS **						
DEPTH	CROSS BRACES						
OF							
TRENCH	HORIZ. SPACING	WIDTH OF TRENCH (FEET)					VERT. SPACING
(FEET)	(FEET)	UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15	(FEET)

5	UP TO 6	6X6	6X6	6X6	6X6	8X8	5
TO	UP TO 8	6X6	6X6	6X6	8X8	8X8	5
10	UP TO 10	6X6	6X6	8X8	8X8	8X8	5
	See Note 1						
10	UP TO 6	6X8	6X8	8X8	8X8	8X8	5
TO	UP TO 8	8X8	8X8	8X8	8X8	8X8	5
	See Note 1						
15	See Note 1						
15	UP TO 6	8X8	8X8	8X8	8X10	8X10	5
TO	See Note 1						
20	See Note 1						
OVER 20	SEE NOTE 1						

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P(a) = 80 \times H + 72$ psf (2 ft Surcharge)

(Continued)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **					
	WALES		UPRIGHTS			
	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)			
			CLOSE			

15	10X12	5	4X6			
TO						
20						
OVER 20	SEE NOTE 1					

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
 ** Manufactured members of equivalent strength may be substituted for wood.

Alternatives to Timber Shoring

Figure 1 - Aluminum Hydraulic Shoring
 (For Figure E-1, [Click Here](#))

Figure 2 - Pneumatic/Hydraulic Shoring
 (For Figure E-2, [Click Here](#))

Figure 3 - Trench Jacks (Screw Jacks)
 Figure 4 - Trench Shields
 (For Figure E-3 & 4, [Click Here](#))

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with 1926.652(b) and (c).

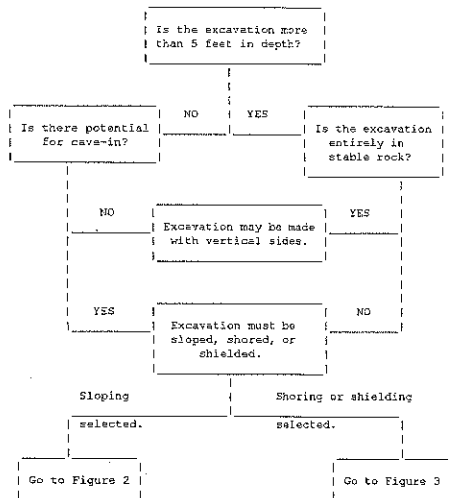


FIGURE 1 - PRELIMINARY DECISIONS

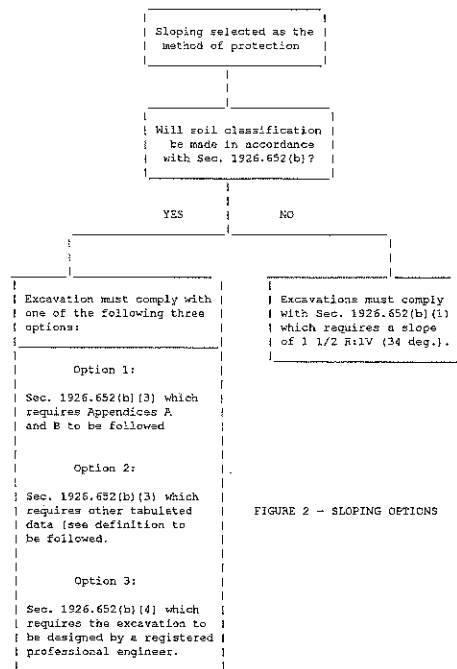


FIGURE 2 - SLOPING OPTIONS

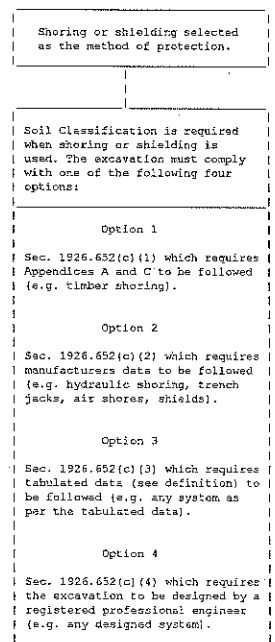


FIGURE 3 - SHORING AND SHIELDING OPTIONS

ATTACHMENT A
TEST PIT LOG

[illegible]

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Appendices

Attachment 1: Foxboro TVA-1000 PID/FID Specifications
Attachment 2: MiniRae® 2000 PID Specifications
Attachment 3: MiniRae® 2000 PID Primer

NOTE: THIS SOP IS A GENERAL DOCUMENT. SITE-SPECIFIC CONDITIONS MAY WARRANT CHANGES IN PROCEDURES AND APPLICATIONS. FIELD STAFF SHALL DOCUMENT ACTUAL PROCEDURES IN THE APPROPRIATE FIELD LOGBOOK.

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for operating and maintaining PID or a combined PID/FID unit. The purpose of this SOP is to document the general protocols for field operations of the selected units.

The Foxboro Toxic Organic Vapor analyzer (TVA-1000) will be used to measure organic vapors using multiple detectors, include the photoionization detector (PID) and a flame ionization detector (FID). The MiniRae® 2000 which uses a single detector (PID only) uses an ultraviolet emitting lamp designed to detect, measure and display the total concentration of airborne ionizable gases and vapors. This information is used to determine control measures such as protection and action levels. The PID also detects total ionizables; hence it is used to monitor both organic and inorganic vapors and gases to determine relative concentrations of air contaminants. The data generated is used to establish level of protection and other control measures such as action levels. The PID cannot effectively detect compounds having ionization potentials above the photon energy level of the lamp used; therefore, methane, which has an ionization potential of 12.98 eV, cannot be detected by PIDs, whose lamps are capable of producing 9.5, 10.6, or 11.7 eV.

The FID is designed to detect and measure organic vapor concentrations by producing a response to an unknown sample, which can be related to a gas of known composition with which the instrument has previously been calibrated. This information is used to determine control measures such as protection and action levels.

2.0 SCOPE AND APPLICATION

FIDs and PIDs are used to detect and measure volatile organic compounds. An FID or PID is typically calibrated to measure the concentration of a known calibration gas. The instrument can detect other volatile organic compounds, but the concentration indicated will not be accurate. Therefore, these instruments are typically used in the field to screen samples or to monitor the environment for health and safety purposes.

Only qualified personnel will be allowed to perform measurements with FIDs and/or PIDs. The subcontractor's Site Safety Officer will determine who is qualified based on experience and demonstrated competence. Those qualified will use FIDs and PIDs in accordance with this SOP and the manufacturer's written instructions.

3.0 DEFINITIONS

Photoionization detector (PID) - ultraviolet emitting lamp designed to detect, measure and display the total concentration of airborne ionizable gases and vapors.

Flame ionization detector (FID) - detect and measure organic vapor concentrations by producing a response to an unknown sample, which can be related to a gas of known composition with which the instrument has previously been calibrated

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures, which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific equipment to be used, and documenting these in accordance with the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Excavation Personnel - It is the responsibility of the excavation personnel to follow industry guidance or project specific procedures for vacuum excavation. The Excavation personnel are responsible for the proper collection of soils and backfilling per the approved SAP.

5.0 INTERFERENCES AND POTENTIAL PROBLEMS

See Section 9.0, Health and Safety.

6.0 EQUIPMENT AND SUPPLIES

Potential equipment needed for site environmental work may include:

- MiniRae® 2000 (PID unit)
- TVA 1000 (PID/FID unit)
- Field data sheets
- Decontamination equipment
- Maps/plot plan
- Safety equipment
- Compass/Global Position System (GPS)
- Tape measure
- Survey stakes, flags
- Camera and film
- Logbook/waterproof pen

7.0 CALIBRATION PROCEDURES

7.1 Calibration of the TVA-1000

The six steps involved in the calibration of the TVA-1000 are as follows:

1. Turn TVA-1000 unit on and allow to warm up. Define concentrations for Span gas for both PID and FID.
2. PID uses Isobutylene at 100 ppm, and the FID uses Methane at 100 ppm. Zero TVA-1000 utilizing zero gas. Calibrate the PID utilizing Isobutylene at 100 ppm
3. Calibrate the FID utilizing Methane at 100 ppm.
4. Update the background concentration.
5. Check values for PID/FID and record these as Calibration Concentration either in Field Logbook or on Data Sheet.
6. Check PID/FID zero. Make sure reading return to zero prior to utilizing for collecting VOC readings.

TVA-1000 should be calibrated to a minimum every day at the beginning of shift, when unit is started, or when baseline shows excessive drift. The calibration concentration should be within 10% of known value.

7.1.1 Maintenance

Removable and renewable parts are included in the Foxboro TVA-1000. The components that may be maintained by operating personnel on an as needed basis include the following:

- Battery
- Hydrogen Tank
- Sintered Metal Filter
- Cleaning of PID/FID lamp

The following sections describe the routine maintenance and instrument adjustments that can be made by trained personnel on a quarterly basis.

- PID cavity - should be removed and cleaned, replaced if needed
- FID cavity - should be removed and cleaned, replaced if needed
- Sample line Fitting - replaced if damaged
- FID end cap and flame arrestor - removed and cleaned, replaced if needed
- Tubing - replaced if damaged
- Charcoal Filter (if applicable) - have charcoal replaced
- Water trap (if applicable) - membrane or membrane support replaced if damaged or worn
- Filter cups - cleaned or replaced
- Close area sampler - checked for damages or clogging, replace if damaged or clogged
- PID Cartridge - cleaned thoroughly
- FID Cartridge - cleaned thoroughly

7.1.2 Battery and Battery Charger

The Ni-Cad battery, supplied with the unit, lasts for a minimum of eight hours of continuous use at 20°C. Severe cold and/or use of the backlight, however, will shorten that time.

A battery charger unit with cable is shipped with the instrument. You do not have to remove the battery for charging. Simply plug the output of the charger, a 6-pin molded connector, into the mating connector marked CHRG in the instrument. Then, insert the charger plug into the

appropriate wall outlet. A green power indicator is ON when the charger is operating. Normal charge time for a fully discharged battery is approximately 16 hours, or two hours of charge for every hour of use.

Do not leave the battery on charge for extended periods (greater than 96 hours). If you wish to remove the battery for charging or swapping with a spare battery, turn the instrument off. Using the special tool supplied with the accessory kit, unscrew the screw on the battery compartment cover on the rear of the instrument and remove the battery cover. As the battery pack fits snugly in the instrument housing, use care in removing the battery pack and its internal connector. As you remove the battery pack, note the location of the battery connector. When re-inserting the battery pack in the instrument, be sure to push the connector into the same location, so that it does not interfere with the battery pack.

To charge the battery when removed from the instrument case, use the adapter supplied with the accessory kit.

7.1.3 Hydrogen Gas Tank

FID-type instruments are supplied with an 85 cc hydrogen gas tank. This tank, which may be pressurized to 2200 psi maximum at 25°C will provide 8 hours operation when fully charged. The tank has an integrally mounted high pressure gauge that can be easily read when the tank is in or out of the instrument. You may install the tank in the instrument by simply inserting the tank into the receptacle on the left side of the instrument and tightening (left hand threads) until the tank seats. Do not overtighten – the O-ring, not the thread, forms the gas seal.

To fill the tank, use the following procedure:

1. Turn supply tank valve OFF.
2. Attach tank fill adapter to supply tank with valve OFF and with manifold valve on OFF position.
3. Attach TVA-1000 hydrogen tank to tank fill adapter. (Note left hand thread – *do not overtighten*.)
4. Open supply valve. Move fill adapter valve to FILL position.
5. Wait for TVA-1000 tank to fill. This may take 2 to 3 minutes because of flow restrictors in the tank and fill adapter.
6. Close fill adapter valve.
7. Remove TVA-1000 tank.
8. Close supply tank valve.
9. Move fill adapter valve to BLEED position.
10. Remove tank fill adapter.

Always remove the tank from the instrument before opening the instrument case for any reason.

7.1.4 Servicing the PID Cartridge

To service the PID cartridge, use the following procedure:

1. Turn the instrument OFF.

2. Using the special spanner wrench provided with the instrument tool kit, unscrew the blue cap holding the PID cartridge in place.
3. Using the special extractor tool provided with the necessary kit, screw the extractor into the cartridge. (Do not exceed three full turns.)
4. Remove the cartridge by pulling on the extractor. Unscrew the extractor from the cartridge. Clean or replace the cartridge.
5. To insert a new cartridge, reverse the procedure. Note that the standard 10.6 eV FID cartridge is marked with a blue band. Other energy level lamps are marked with different colors (not red).

To clean a PID lamp window, use the following procedure:

1. Remove the cartridge from the instrument, as described above.
2. Clean the window of the lamp, using the materials supplied with the optional PID lamp cleaning kit. Follow the instructions included with the cleaning kit, being careful never to touch the window with your bare fingers.
3. When the cartridge is dry (dry at 40°C to 55°C for 1 hour), screw the extractor into the cartridge and re-insert it into the instrument.
4. Screw in the blue PID detector cap, using the special spanner wrench supplied with the tool kit. Do not overtighten cap.

7.1.5 Servicing the FID Cartridge

To remove the FID cartridge, use the following procedure:

1. Close the hydrogen supply valve on the side of the instrument. Turn the instrument off.
2. Using the special spanner wrench provided with the instrument tool kit, unscrew the red cap holding the FID cartridge in place.
3. Using the special extractor tool provided with the accessory kit, screw the extractor into the cartridge.
4. Remove the cartridge by pulling on the extractor. Unscrew the extractor from the cartridge. Clean or replace the cartridge.
5. To insert a new cartridge, reverse the procedure. Note that a FID cartridge is marked with a red band.

To clean a FID cartridge, you will need a cotton swab and some isopropyl alcohol. Dip the swab into the isopropyl alcohol and insert it into the center of the cartridge. Swab the surface until clean and discard the swab. Then dry the cartridge in an oven at 45°C to 55°C for one hour. When dry, re-insert the cartridge into the instrument, reversing the removal procedure. Do Not overtighten cap.

7.1.6 Other Maintenance

Additional optional features and maintenance activities for the TVA-1000 are listed in the operator's manual. Please see the manual for protocols on the following:

- The use of the telescoping extension option
- The use of the activated charcoal scrubber
- Cleaning or replacing a sintered metal probe filter

- Replacing the probe tubing
- Replacing the sampling pump

The manufacturer's operating manual will be used for the operation, calibration, maintenance, and care of FIDs and PIDs. The manual will be present on site at all times.

7.2 Calibration of the MiniRae® 2000

The MiniRae® 2000 PID will be used to measure organic vapors. The PID uses an ultraviolet emitting lamp designed to detect, measure and display the total concentration of airborne ionizable gases and vapors. The PID detects total ionizables; hence it is used to monitor both organic and inorganic vapors and gases to determine relative concentrations of air contaminants. The data generated is used to establish level of protection and other control measures such as action levels. The PID cannot effectively detect compounds having ionization potentials above the photon energy level of the lamp used; therefore, methane, which has an ionization potential of 12.98 eV, cannot be detected by PIDs, whose lamps are capable of producing 9.5, 10.6, or 11.7 eV. A 10.6eV lamp is typically used unless otherwise specified for project requirements.

PIDs are used to detect and measure volatile organic compounds. A PID is typically calibrated to measure the concentration of a known calibration gas. The instrument can detect other volatile organic compounds, but the concentration indicated will not be accurate. Therefore, these instruments are typically used in the field to screen samples or to monitor the environment for health and safety purposes. Only qualified personnel will be allowed to perform measurements with PIDs.

7.2.1 Calibration Procedures

Calibration will be performed prior to PID use every day the instrument is used, and recorded in the field log-book. The following additional information shall be recorded:

1. Date/Time of measurement
2. The first meter reading obtained with calibration gas to either adjust instrument or note how far off the instrument is drifting
3. Results
4. Calibrator's Name

Calibrate the MiniRae® 2000 by taking a sample for ZERO using the charcoal filter provided with the instrument. The SPAN sample must be a known concentration of a calibration gas. Isobutylene (IBE) at 100 ppm will be used. Enter the concentration of the span gas (display reads GASCONC) then assign a sensitivity level for the gas to be measured (display reads Response Factor).

Two calibration techniques are available using the MiniRae® 2000: fresh air calibration and span gas calibration. These are described in the following sections.

Fresh Air Calibration

1. The first sub-menu shows: "Fresh air Cal?"
2. Make sure that the MiniRae® 2000 is connected to one of the "fresh" air sources (charcoal filter)
3. Press the [Y/+] key, the display shows "zero in progress" followed by "wait..." and countdown timer.
4. After about 15 seconds pause, the display will show the message "zeroed reading = x.x ppm..." Press any key or wait about 20 seconds, the monitor will return back to "Fresh air Calibration?" submenu.
5. The charcoal filter has a check box so that user can mark off a box each time the filter has been used. The charcoal filter should be replaced after 4 calibrations.

Span Gas Calibration

This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is needed to perform this procedure. Choose 500 cc/min. regulator is needed to perform this procedure. Choose 500 cc/min. regulator only because the flow rate matches the flow rate of the pump inside. Alternatively, the span gas can first be filled into a Tedlar Bag.

1. Connect the calibration adapter to the inlet port of the MiniRae® 2000 monitor, and connect the tube to the regulator or Tedlar bag.
2. Make sure the monitor is connected to one of the span gas sources described above.
3. Press the [Y/+] at the "Span Cal?" to start the calibration. The display shows the gas name (Isobutylene) and the span value of the corresponding gas (100 ppm).
4. The display shows "Apply gas now!" Turn on the valve of the span gas supply. Display shows "wait... 30" with a count down timer showing the number of remaining seconds while the monitor performs the calibration.
5. To abort the calibration, press any key during the count down. The display shows "Aborted!" and return to "Span Cal?" sub-menu.
6. When the count down timer reaches 0, the display shows the calibrated value. The reading should be close to the span gas value + 10 ppm. During calibration, the monitor waits for an increased signal before starting the countdown timer. If a minimal response is not obtained after 35 seconds, the monitor displays "No Gas!" Check that the span gas valve is on and for lamp or sensor failure before trying again.
7. The calibration can be started manually by pressing any key while the "Apply gas now!" is displayed. After a span calibration is completed, the display will show the message "Span Cal Done! Turn Off Gas" Turn off the flow of gas. Disconnect the calibration adapter or Tedlar bag from the MiniRae® 2000 monitor. Press any key and it returns back to "Span Gas Cal?"

7.2.2 Maintenance

Removable and renewable parts are included in the MiniRae® 2000 maintenance kit. The components that may be maintained or replaced by operating personnel include the following:

- Battery
- Calibration Gas Tank
- Charcoal Filter
- Tubing
- Moisture Filter

The manufacturer's operating manual will be used for the maintenance and care of the PID unit. If problems should occur, the trouble-shooting guide found in Table 7.2.1 of the MiniRae® 2000 operating manual (page 7-1 and 7-2 of Attachment 2), should be consulted. The manual will be present on site at all times.

8.0 QUALITY ASSURANCE RECORDS

Use of any PID or PID/FID analyzer will be in accordance with the Health and Safety Plan or other SOPs requiring its use. Observations or calculations will be documented by personnel in a bound, waterproof field notebook. Entries may also be entered on boring logs. Entries will be signed and dated by field personnel making the entries and will include daily calibrations. At a minimum the following will be recorded:

- Date/Time of measurement
- Initial Response - Initial Response is the first meter reading obtained with calibration gas to either adjust instrument or note how far off the instrument is drifting
- Calibration protocol (last calibration date/time)
- Results
- Calibrator's Name

Specific quality assurance activities which may apply to the implementation of these procedures include the following:

- All data must be documented on field data sheets or within site logbooks. The following information shall be recorded in the field logbook:
 - Project location, date and time.
 - Weather.
 - Excavation location number.
 - Sketch of excavation location including boundaries of buildings, roadways, etc.
- All excavation equipment must be operated by the excavation vendor using licensed professionals in accordance with operating instructions.

- Equipment checkout must occur prior to sampling/operation and they must be documented.

9.0 HEALTH AND SAFETY

The major hazard associated with the handling the TVA-1000 is hydrogen which is flammable. The following specific rules apply when handling hydrogen:

1. Never use cylinders of hydrogen in areas where flames, excessive heat, or sparks may occur.
2. Use only explosion-proof equipment and sparkproof tools in areas where hydrogen is handled.
3. Ground all equipment and lines used with hydrogen.
4. Never use a flame to detect hydrogen leaks - use soapy water.
5. Do not store reserve stocks of hydrogen with cylinders containing oxygen or other highly oxidizing or combustible materials.
6. Store hydrogen tanks in well ventilated area.

The major hazard associated with the handling the MiniRae® 2000 is associated with the use of external jacks and battery charging. Do not connect external cable to serial interface jack, or charge batteries in any hazardous environments.

10.0 REFERENCES

RAE Systems, 2001. "PIDs for Continuous Monitoring of VOCs" Application Note (AP-211, Revision 5, 2001).

RAE Systems, 2001. "Using PIDs for Assessment of Exposure Risk in Unknown Environments" Application Note (AP-221, cw/01).

RAE Systems, 2005. "MiniRae® 2000 Portable VOC Monitor, PGM-7600, Operations and Maintenance Manual" (Document 011-4001-000, Revision E, 2005).

USEPA, 1986. "RCRA Groundwater Monitoring Technical Enforcement Guidance Document. EPA OSWER.9950.1. September 1986.

USEPA, 1987. "A Compendium of Superfund Field Operations Methods" EPA/540/P-87/001. December 1987.

Attachment 1

Introduction

MI 611-180 - September 1993

WARNING: Do not connect any electrical device (such as battery charger, analog output, personal computer, or auxiliary port device) to the instrument in an area classified as hazardous due to the presence of flammable gases or vapors.

Standard Specifications

Accuracy	PID Instrument — ±25% of reading or ±2.5 ppm, whichever is greater, from 0.5 to 500 ppm. Accuracy listed is achieved using isobutylene with a 1-point calibration in the range from 100 to 300 ppm (including drift) at the temperature and humidity of the calibration. FID Instrument — ±25% of reading or ±2.5 ppm, whichever is greater, from 1.0 to 10,000 ppm. Accuracy listed is achieved using methane with a 1-point calibration in the range from 100 to 500 ppm (including drift) at the temperature and humidity of the calibration.
Repeatability	PID Instrument — ±1% at 100 ppm of isobutylene FID Instrument — ±2% at 100 ppm of methane
Analog Output	Two analog output signals, 0 to 2 V dc, proportional to the count output from each detector.
Dynamic Range	PID Instrument — 0.5 to 2,000 ppm of isobutylene FID Instrument — 1.0 to 50,000 ppm of methane
Linear Range	PID Instrument — 0.5 to 500 ppm of isobutylene FID Instrument — 1.0 to 10,000 ppm of methane
Minimum Detectable Level	The minimum detectable level is defined as two times the peak-to-peak noise. PID Instrument — 100 ppb of benzene FID Instrument — 300 ppb of hexane
Response Time using close area sampler	PID Instrument — Less than 3.5 seconds for 90% of final value, using 100 ppm of isobutylene FID Instrument — Less than 3.5 seconds for 90% of final value, using 10,000 ppm of methane
Recovery Time using close area sampler	PID Instrument — Less than 5.0 seconds to return to 10% of base line, using 100 ppm of isobutylene FID Instrument — Less than 5.0 seconds to return to 10% of base line, using 10,000 ppm of methane

Standard Specifications

3

Response Time using telescoping wand extender	<i>FID Instrument</i> — Less than 5.0 seconds for 90% of final value, using 100 ppm of isobutylene <i>FID Instrument</i> — Less than 5.0 seconds for 90% of final value, using 10,000 ppm of methane
Recovery Time using telescoping wand extender	<i>FID Instrument</i> — Less than 5.0 seconds to return to 10% of base line, using 100 ppm of isobutylene <i>FID Instrument</i> — Less than 5.0 seconds to return to 10% of base line, using 10,000 ppm of methane
Response Time using charcoal filter adapter	<i>FID Instrument</i> — Less than 20 seconds for 90% of final value, using 100 ppm of isobutylene <i>FID Instrument</i> — Less than 20 seconds for 90% of final value, using 10,000 ppm of methane
Recovery Time using charcoal filter adapter	<i>FID Instrument</i> — Less than 20 seconds to return to 10% of original value, using 100 ppm of isobutylene <i>FID Instrument</i> — Less than 20 seconds to return to 10% of original value, using 10,000 ppm of methane
Data Storage Rate	From 1 per second to 1 per 999 minutes, user selectable
Sample Flow Rate	1 l/minute, nominal, at sample probe inlet
Battery	The battery can be fully charged in less than 16 hours. The battery operating time is 8 hours minimum at 20° (32°F). Use of the backlight on the probe display shortens battery life. The battery is replaceable by removing the bottom cover of the instrument. <i>(WARNING: Do not replace battery in an area classified as hazardous due to presence of flammable gases or vapors.)</i>
Battery Charger	The battery charger is a separate unit designed to be mounted on a table top. It is capable of operating the analyzer while simultaneously charging the internal battery. An adapter cable is provided to charge the battery safely from the charger. The charger can charge a fully discharged battery in a maximum of 16 hours. Charging takes longer if performed while the instrument is operating. Two types of chargers are available, one for 120 V ac 50/60 Hz and another for 230 Vac, 50/60 Hz. <i>(WARNING: Do not operate battery charger in an area classified as hazardous due to presence of flammable gases or vapors.)</i>
PID Lamp Life	Greater than 2000 hours for 10.6 eV lamp, with normal cleaning
FID Life	Greater than 2000 hours
Audio Output Level	Greater than 75 dB at 3 feet

Attachment 2

Gas Cylinder Capacity	Pressure— 15.3 MPa at 25°C (2200 psi at 77°F) maximum Empty— 85 cc (5.19 in ³)
Hydrogen Supply Operating Time	Greater than 8 hours of continuous operation, starting from a cylinder charged up to 15.3 MPa (2200 psi)
Enclosure Description	The analyzer enclosure and front panel are made from a thermoplastic material. The approximate dimensions are 343 x 262 x 81 mm (13.5 x 10.3 x 3.2 in). The enclosure is designed to provide the environmental protection of NEMA Type 3R (rain, snow, and sleet).
Electrical Interface Connections	Mating female connectors for Analog Output, RS-232 Interface, and Battery Charger are provided on the side of the analyzer case below the keypad.
Mechanical Connections	Mechanical connections for Sample Input and for Vent Outlet are provided on the side surfaces.
Portability	The analyzer is designed to be carried by a removable shoulder strap. The strap, which is provided with every instrument, does not hinder the user when viewing or using the analyzer front panel. The strap is designed to support the probe when the instrument is not in use.
Transportation Case	A specially designed thermoplastic case is provided for transporting the analyzer and all of its accessories in a personal vehicle or common carrier. It is of rugged construction and is fitted with shock and vibration absorbing material.
Tool Kit	An accessory tool kit is provided with each instrument. The kit contains special tools for accessing the battery and removing the detector capsules.
Approximate Mass	<i>Analyzer (PID plus FID)</i> — 5.2 kg (11.5 lb) <i>Probe Assembly</i> — 0.55 kg (1.2 lb) <i>Transportation Case</i> — Less than 4.5 kg (10 lb)

Standard Specifications

5

MiniRAE 2000

Portable VOC Monitor
PGM-7600



OPERATION AND MAINTENANCE MANUAL

(Document No.: 011-4001-000)
Revision E, May 2005



ATTENTION!

For European Applications

- A. CE 0575 0111G/2G
DEMKO 03 ATEX 0204759X
Ex ia IIC T4
- B. Recharge batteries only in non-hazardous locations.
- C. Do not connect external cable to serial interface jack in hazardous locations.
- D. Use RAE Systems Adapter P/N 500-0072 for connection to communication port and charging jack only in a non-hazardous area.

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⚠ WARNING ⚠

- Do NOT proceed before reading -

This manual must be carefully read by all individuals who have or will have the responsibility for using, maintaining, or servicing this product.

The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions.

CAUTION!!

To reduce the risk of electric shock, turn off power before removing the monitor cover. Disconnect the battery before removing sensor module for service. Never operate the monitor while the cover is removed. Remove monitor cover and sensor module only in an area known to be non-hazardous.

The model PGM-7600 equipment is classified as to intrinsic safety for use in class I, division 1, groups A, B, C, D, or non-hazardous locations only.

Special Notes

-1-

When the MiniRAE 2000 Monitor is taken out from the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the monitor. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

-2-

The battery of the MiniRAE 2000 monitor will discharge slowly even if it is turned off. If the monitor has not been charged for 5-7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the monitor before using it. It is also recommended to fully charge the monitor FOR AT LEAST 10 HOURS before first use. See Section 7 for more information on battery charging and replacement.

iv

AVERTISSEMENTS

DANGER RISQUE D'ORIGINE ELECTROSTATIQUE:
Nettoyer uniquement avec un chiffon humide.

Pour des raisons de sécurité, cet équipement doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Utiliser seulement l'ensemble de batterie RAE Systems, la référence 012-3050, 012-3051 ou 012-3052. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsèque. Ne charger les batteries que dans emplacements désignés non-dangereuse.

La calibration de toute instruments de RAE Systems doivent être testé en exposant l'instrument à une concentration de gaz connue par une procédure d'étalonnage avant de mettre en service l'instrument pour la première fois.

Pour une sécurité maximale, la sensibilité du MiniRAE 2000 doit être vérifiée en exposant l'instrument à une concentration de gaz connue par une procédure d'étalonnage avant chaque utilisation journalière.

vi

WARNINGS

STATIC HAZARD: Clean only with damp cloth.

For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part nos. 012-3050, 012-3051 or 012-3052. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

For maximum safety, the accuracy of the MiniRAE 2000 should be checked by exposing it to a known concentration calibration gas before each day's use.

v

GENERAL INFORMATION

1. GENERAL INFORMATION

MiniRAE 2000 Portable VOC Monitor (Model PGM 7600) is a compact monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a Photo-Ionization Detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas discharge lamp. Features are:

- **Lightweight and Compact**
 - Compact, light weight (19 oz.) and rugged design
 - Built-in sample draw pump
- **Dependable and Accurate**
 - Up to 10 hours of continuous monitoring with rechargeable battery pack
 - Designed to continuously monitor VOC vapor at ppm levels
- **User Friendly**
 - Preset alarm thresholds for STEL, TWA, low and high level peak values. Audio buzzer and flashing LED display are activated when the limits are exceeded.
- **Datalogging Capabilities**
 - 15,000 point datalogging storage capacity for data download to PC

MiniRAE 2000 consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged ABS + PC case with a backlit 1 line by 8 character dot matrix LCD and 3 keys to provide easy user interface.

1-1

1.1 General Specifications

Table 1.1

Portable VOC Monitor Specification	
Size:	8.2"L x 3.0"W x 2.0"H
Weight:	19.5 oz with battery pack
Detector:	Photo-ionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 4.8V /1250 mAh Rechargeable Nickel Metal Hydride battery pack (snap in, field replaceable)
Battery Charging:	10 hours charge through built-in charger
Operating Hours:	Up to 10 hours continuous operation
Display:	1 line by 8 characters 5x7 dot matrix LCD (0.4" character height) with LED back light automatically in dim light
Range, Resolution & Response time (t ₉₀):	
Isobutylene (calibration gas)	
	0-99 ppm 0.1 ppm 2 sec
	100-1,999 ppm 1.0 ppm 2 sec
	2000-10,000 ppm 1.0 ppm 2 sec
Measurement Accuracy (Isobutylene):	
	0 - 2000 ppm: ± 2 ppm or 10% of reading.
	> 2000 ppm: $\pm 20\%$ of reading
PID Detector:	Easy access to lamp and sensor for cleaning and replacement
Correction Factors:	Built-in 102 VOC gases
Calibration:	Two-point field calibration of zero and standard reference gas
Calibration Memory:	Store up to 8 separate calibration, alarm limits and span value
Inlet Probe:	Flexible 5" tubing
Keypad:	1 operation key and 2 programming keys

1-2

OPERATION

2. OPERATION OF MINIRAE 2000

The MiniRAE 2000 Portable VOC Monitor is a compact Monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment the MiniRAE 2000 is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, the user should test the instrument and verify the calibration before the first use. After the monitor is fully charged and calibrated, it is ready for immediate operation.

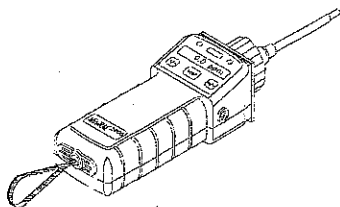


Figure 2-1 MiniRAE 2000

2-1

Direct Readout:	Instantaneous, average, STEL and peak value, battery voltage and elapsed time
Intrinsic Safety:	UL & cUL Class I, Division I, Group A,B,C,D, Temperature Code T3C (US & Canada); C ϵ 0575 @ II 1 G DEMKO 02 ATEX 0204759 Ex ia IIC T4 (Europe)
EM Interference:	No effect when exposed to 0.43 W/cm ² RF interference (5 watt transmitter at 12 inches)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Survey or Hygiene mode
Alarm:	90 dB buzzer and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure.
External Alarm:	Optional plug-in pen-size vibration alarm or remote alarm
Alarm Mode:	Latching or automatic reset
Real-time Clock:	Automatic date and time stamps on data logged information
Datalogging:	15,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC through RS-232 port
Sampling Pump:	Internally integrated. Flow rate: 450-550 cc/min.
Temperature:	0° to 45°C (32° to 113°F)
Humidity:	0 % to 95 % relative humidity (non-condensing)
Housing:	ABS + PC, conductive coating, splash and dust proof, will withstand 1 meter drop test with rubber boot
Attachment:	Wrist strap, rubber boot and belt clip

1-3

OPERATION

2.1 Physical Description

The main components of the MiniRAE 2000 Portable VOC monitor include:

- Three keys for user to interact with the monitor: 1 operation key and 2 programming keys for normal operation or programming of the monitor
- LCD display with back light for direct readout and calculated measurements
- Buzzer and red LED's for alarm signaling whenever the exposures exceed preset limits
- Wrist strap
- Charge contact for plugging directly to the charging station
- Gas entry and exit ports
- Serial communication port for PC interface
- External alarm and analog output port
- Protective rubber cover

2-2

2.2 Keys and Display

Figure 2.2 shows the LCD display and the keypad on the front panel of the monitor. The function of the 3 keys during normal operation are summarized below:

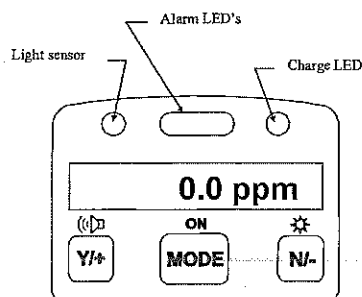


Figure 2-2 LCD Display and Keypad

Key Function in Normal Operation

[MODE]	-Turn on/off the power* and step through menu items
[N/-]	-Toggle on/off the back light, negative acknowledge, decrease value
[Y/+]	-Start measurement, positive acknowledge, increase value

* Pressing and holding [MODE] key for 5 seconds turns off the power to the monitor. Monitor will beep once per second and display countdown timer during power-down sequence. Press [MODE] key momentarily to step through menu items. To save time, press any key during message scrolling to skip to the end of the message.

2.4 Operation

The MiniRAE 2000 VOC monitor has two operation modes: Survey and Hygiene mode. The Survey mode allows the user to manually start and stop the monitoring/measuring operation and display certain exposure values. In the Hygiene mode, the monitor runs continuously after the monitor is turned on. Refer to Section 4.7.1 for switching between the two modes.

2.3 Power On/Off

To turn on the MiniRAE 2000 portable VOC monitor, press [MODE] key for one second and release. The audio buzzer will beep once and the air pump will turn on. The display will show "ON!" and then "Ver n.nn" to indicate the unit's current firmware version number. Next displayed are the serial number, the model number, Operating mode, current date and time, unit internal temperature, gas selected, high low, STEL, TWA/AVG alarm limits, battery voltage, and shut off voltage. Also displayed are internal mode settings such as User mode, Alarm mode, datalog time remaining and log periods in the respective order.

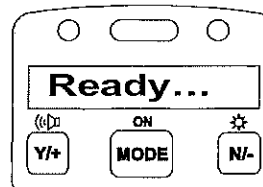
To turn off the MiniRAE 2000 portable VOC monitor, press and hold the [MODE] key for 5 seconds. The monitor will beep once per second during the power-down sequence with a count down timer showing the number of remaining seconds. The message "Off!" flashes on the LCD display and the display will go blank indicating that the monitor is turned off.

Data protection during power off

When the monitor is turned off, all the current real time data including last measured value are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost. While the power is off, the real time clock will continue to operate until the battery is completely drained (usually in 4-5 days without any charging). If the battery is completely drained or is disconnected from the monitor for more than 30 minutes, the real time clock will be lost. In this case, the user needs to enter the real time clock information again, as described in Section 4, or send the PC clock during configuration through the PC communication.

2.4.1 Survey Mode

After the monitor is turned on, it runs through the start up menu. Then the message "Ready..." is displayed (see figure below).



At this point, the user has two options:

1. Step through the Main Menu.
2. Take a measurement.

Press the [MODE] button to step through the Main Menu. Press the [Y/+] button to proceed to take a measurement.

The Main Menu

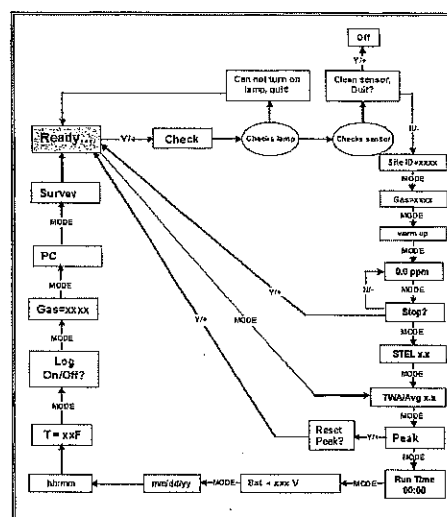
Press the [MODE] button to enter the Main Menu. Press the [Y/+], [MODE] or [N/-] as indicated in the flow chart below to step through the Main Menu. The PID sensor and pump are turned off during this time.

The Main Menu functions are:

- Ready...
- Check
- Site ID = xxxx
- Gas = xxxx
- Warm up
- X.x ppm
- Stop?
- TWA/Avg x.x ppm
- STEL x.x ppm
- Peak x.x ppm
- Run time hh:mm
- Bat = X.XV
- Mm/dd/yy
- hh:mm
- T = xxxF [date, time and temperature (°C or °F)]
- Log On/Off?
- PC Comm?
- Survey

2-7

These functions are arranged in a "round robin" order. To select a specific function, press the button as shown below until the desired function appears.

Main Menu

2-8

The Main Menu Functions

- **Ready...** Indicates that the monitor is ready to take a measurement or to step through the Main Menu. Press the [Y/+] button to advance to taking a measurement (read "Taking a Measurement" on Page 2-12 for details).

Note: The Ready... screen is skipped if the menu is cycled through while a measurement is running.

- **Check...** This message displays while the system is checking the lamp and the sensor. If the lamp test succeeds, the system will progress to checking the sensor. If the lamp test does not succeed, the display will read **Can not turn on lamp, quit!**
 - **Can not turn on lamp, quit!** This message displays when the lamp does not turn on. The system will automatically return to Ready... allowing the user to test the lamp again. If the lamp fails a second time, turn the monitor off and refer to Section 7.2 "PID Sensor & Lamp Cleaning / Replacement".
 - **Clean Sensor, Quit?** This message displays when the sensor requires cleaning. Press the [Y/+] button to turn the monitor off and clean the sensor. Press the [N/-] button and the system will progress to the Site ID = xx
- **Site ID = xxxx:** This display shows the Site ID and indicates that the monitor is about to start taking measurements (read "Taking a Measurement" for details)

Note: This display appears only after a measurement has been started. It does not appear when the user is cycling through the Main Menu and the monitor is idling.
- **Gas = xxxx:** This display identifies the gas to be measured and indicates that the monitor is about to take a measurement (read "Taking a Measurement" for details)

2-9

Note: This display appears only after a measurement has been started. It does not appear when the user is cycling through the Main Menu and the monitor is idling.

- **x.x ppm:** (read "Taking a Measurement" for details)

Note: This display appears only after a measurement has been started. It does not appear when the user is cycling through the Main Menu and the monitor is idling.
- **TWA/Avg:** Displays (in ppm) the Time Weighted Average (TWA) or the Average since the start of the measurement. The average is recalculated every minute.
- **STEL:** Displays the Short Term Exposure Limit.
- **PEAK:** Displays (in ppm) the highest instantaneous reading since the start of the measurement. If [Y/+] is pressed while the peak reading is displayed, the unit will ask **Reset Peak?**. If [Y/+] is pressed again, the peak value will be cleared and the display will return to the Ready... message or instantaneous reading. The peak reading is automatically reset when a new measurement is started by pressing [Y/+] from the Ready... screen.
- **Run time hh:mm:** The duration of the current measurement period.
- **Bat = X.XV:** The current battery voltage.

Note: A fully charged battery pack should show 4.8 volts or higher. When the battery voltage falls below 4.4 volts, a flashing "Bat" will appear as a warning message. At that point, you have 20-30 minutes of run time remaining. When the battery voltage falls below 4.2 volts the monitor turns off automatically.
- **Mm/dd/yy:** The current date.
- **hh:mm:** The current time (24-hour format)

2-10

- **T = xxxF:** The internal unit temperature in degrees Fahrenheit. (see Section 4.7.13 to change temperature units)
- **Log on/Off?:** Allows the user to start datalogging of the current measurement. A superscript "L" flashes in the ppm measurement display when datalogging is on. This screen is not shown when datalogging is disabled or when the monitor is not operating in manual start/stop mode.

- **PC Comm?:** This function enables the user to upload data from the MiniRAE 2000 to a Personal Computer (PC) or send/receive configuration information between a PC and the MiniRAE 2000. Press [MODE] to return to Ready...

To communicate with a PC, connect the monitor to the serial port of a PC and start the MiniRAE 2000 application software. Press the [Y/+] button and the LCD displays "pause monitor, ok?" Press the [Y/+] button one more time, and the display shows "Comm..." The monitor is now ready to receive commands from the PC.

- **Survey:** This function displays the Current Operating Mode (Survey or Hygiene).

Taking a Measurement

There are two ways to start a measurement.

1. Operating in Hygiene mode.
2. Manually start and stop measurement in Survey mode.

To start a measurement in Hygiene mode, please refer to Section 4.7.1, "Change Operation Mode". To start a measurement in Survey Mode, the MiniRAE 2000 monitor must first be in the "Ready..." mode. This is the mode to which the monitor normally powers up.

Measurement phases

1. Ready
2. Start measurement
3. Measurement display and datalogging
4. Stop measurement

Ready

The display reads Ready... indicating the unit is ready to start a measurement.

Start Measurement

Press the [Y/+] button to start the check cycle (see above), and then the measurement cycle.

After completing the Check cycle, the display will show the Site ID and then the Gas selected for measurement. The pump will start and the reading will be displayed. The Peak and Average values will be automatically reset to zero.

Measurement Display and Datalog

Instantaneous readings of the gas concentration in parts per million (ppm) are updated every second. A flashing superscript L is displayed when datalogging is on. Datalog information is saved only after one full datalog period is completed.

Stop Measurement

Press the [MODE] button and the display shows Stop? Press [N/-] to continue measurement and [Y/+] to stop the measurement and datalog event. The pump stops automatically when measurement is stopped. Peak and average values for the current measurement can be read in idle mode until a new measurement is started.

Automatic Increment of Site ID

Every time a measurement is taken, the site ID will be incremented by one automatically in Survey mode.

Variable Alarm Signal

In Survey Mode, if the measurement exceeds the low alarm limit, the buzzer and flashing alarm are activated and will beep/flash once per second. The alarms will increase in frequency as the gas concentration approaches the high alarm limit reaching 8 times per second when the high alarm has been exceeded.

Press [Y/+] key to clear if latching alarm.

2.4.2 Hygiene Mode

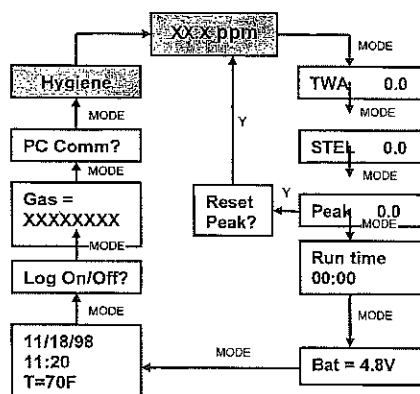
In Hygiene Mode, the unit will continuously taking measurements, once the power is turned on. After the initial start-up sequence displaying the current monitor settings, the LCD displays the instantaneous readings.

The Hygiene operation menu displays include:

- Real time readings in ppm
- Current TWA/Avg, STEL and Peak values (see Section 4.6.6)
- Run time
- Current battery voltage
- Date, time and temperature
- Log on/off?
- Gas name
- PC communication?
- Hygiene

Detailed description of most of these displays are the same as Section 2.4.1.

HYGIENE MODE MAIN MENU



To choose a specific display, press the [MODE] key one or more times until the desired display appears, or the [Y/+] key where indicated with a Y.

Note: To get back to instantaneous reading from any of the above display, press [MODE] key repeatedly until the "XX.X ppm" display appears.

2.5 Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings: Low, High, TWA and STEL). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn the user of the alarm condition.

In addition, the MiniRAE 2000 will alarm if one of the following conditions occurs: battery voltage falls below a pre-set voltage level (4.4 V), failure of UV lamp, pump stall, or when the datalog memory is full. When the low battery alarm occurs, there will be approximately 20-30 minutes of operating time remaining. When the battery voltage falls below 4.2 V, the monitor will turn off automatically.

Alarm Signal Summary:

Condition	Alarm Signal
Gas exceeds "High Alarm" limit	3 beeps/flashes per second
Gas exceeds "Low Alarm" limit	2 beeps/flashes per second
Gas exceeds "TWA" limit	1 Beeps/flashes per seconds
Gas exceeds "STEL" limit	1 Beeps/flashes per seconds
Pump failure	3 beeps/flashes per second plus "Pump" message on LCD
PID lamp failure	3 beeps/flashes per second plus "Lamp" message on LCD
Low battery	1 flash per second, 1 beep per minute plus "Bat" message on LCD
Memory full	1 flash per second plus "Mem" message on LCD

Alarm Signal Testing:

Under normal non-alarm conditions, it is possible to test the MiniRAE 2000 LED and buzzer in Special Diagnostic Mode (see Section 8 for details).

2.6 Preset Alarm Limits and Calibration

The MiniRAE 2000 portable VOC monitor is factory calibrated with standard calibration gas, and is programmed with default alarm limits. There are 102 gas settings stored in the library. Some examples of calibration and alarm limits are shown below. Refer to Section 4 on programming procedures for selecting a different gas, perform a calibration or set new alarm limits.

Factory Calibration and Preset Alarm Limits

Cal Gas	Cal Span	unit	Low	High	TWA	STEL
Isobutylene	100	ppm	50	100	100	250
Hexane, n-	100	ppm	500	750	500	750
Xylene, m-	100	ppm	100	150	100	150
Benzene	5	ppm	2	5	5	2
Styrene	50	ppm	20	40	20	40
Toluene	100	ppm	50	100	50	100
Vinyl Chloride	10	ppm	5	10	5	10
Custom	100	ppm	50	100	50	100

2.7 Integrated Sampling Pump

The MiniRAE 2000 portable VOC monitor includes an integrated sampling pump. This is a diaphragm type pump that provides a 500-600 cc per minute flow rate. Connecting a Teflon or metal tubing with 1/8 inch inside diameter to the gas inlet port of the MiniRAE 2000, this pump can pull in air samples from 200 feet away horizontally, or 90 feet vertically, at about 3 feet per second flow speed.

The pump turns on when a measurement is started, and turns off when the sample is manually stopped in Survey mode or when the unit is turned off from Hygiene Mode.

If liquid or other objects are pulled into the inlet port filter, the monitor will detect the obstruction and shut down the pump immediately. The alarm will be activated and a flashing error message "Pump" will be also displayed on the LCD display.

The user should acknowledge the pump shut off condition by clearing the obstruction and pressing the [Y/+] key to re-start the pump.

The pump stall threshold is set in the special Diagnostic Mode (Section 8).

2.9 Datalogging

During datalogging, the MiniRAE 2000 Portable VOC monitor flashes a superscript "L", on the display to indicate that datalogging is enabled. The monitor stores the time stamp, sample number, and measured gas concentration at the end of every sample period (when data logging is enabled). In addition, the following information are stored: user ID, site ID, serial number, last calibration date, and alarm limits. All data are retained (even after the unit is turned off) in non-volatile memory so that it can be down loaded at a later time to a PC.

Datalogging event

When Datalogging is enabled, measurement readings are being saved. These data are stored in "groups" or "events." A new event is created and stored each time the monitor is turned on, or a configuration parameter is changed, or datalogging is interrupted (e.g. Communication with PC during Hygiene mode). Information, such as start time, user ID, site ID, gas name, serial number, last calibration date, and alarm limits will be recorded.

Datalogging sample

After an event is recorded, the unit records a shorter form of the data. This data contains: the sample number, time (hour/minute) and gas concentration.

2.8 Back Light

The LCD display is equipped with an LED back light to assist in reading the display under poor lighting conditions. Pressing and holding the [N/-] key for one second in normal operation can turn on the backlight. The backlight can be turned off by pressing [N/-] a second time. If the [N/-] key is not pressed, the back light will be turned off automatically after a pre-programmed time-out period to save power.

In addition, the ambient light is sensed and the back light will be turned on automatically if the ambient light is below a threshold level. The back light is turned off automatically when the ambient light exceeds the threshold level.

See Section 8 for instructions on how to set the light threshold level.

Note: The LED backlight consumes about 20-30% of the total average current, when the instrument is idle or not taking a measurement.

3. OPERATION OF ACCESSORIES

The accessories for the MiniRAE 2000 include:

- An AC Adapter (Battery Charger)
- Alkaline battery holder
- Water Trap Filter

Optional Accessories:

- Dilution Fitting
- Calibration adapter
- Calibration regulator and Flow controller
- Organic Vapor Zeroing kit

3.1 Standard Kit and Accessories

1) AC Adapter (Battery Charger)

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

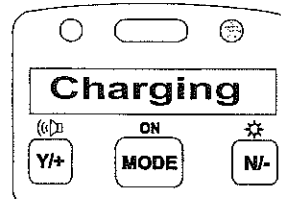
Ne charger les batteries que dans emplacements designés non-dangereuses.

A battery charging circuit is built into the MiniRAE 2000 monitor. It only needs a regular AC to 12 V DC adapter (wall mount transformer) to charge the monitor.

To charge the battery inside the MiniRAE 2000 monitor:

1. Power off the Monitor.
2. Connect the AC adapter (or the optional automotive charging adapter) to the DC jack on the MiniRAE 2000 monitor. If the unit was off, it will automatically turn on.
3. The first message displayed will be "Deep discharge?" The unit will ask this question for three times. If the user wants to discharge the battery pack, affirm this query with the [Y/+] key, otherwise the unit will move on to the charge mode directly.

4. While charging, the display message will alternate between "Charging" and "Bat=x.xV" (x.x is the present battery voltage). The LED should be red in color when charging.



5. When the battery is fully charged, the LED will change from red to green and the message "Fully charged" will appear on the display. After the battery is fully charged, the unit will enter the "trickle charge" mode. In which, the red LED will turn on for several seconds every minute, to maintain the full charge.

A completely discharged MiniRAE 2000 monitor will be charged to full capacity within 10 hours. The battery will be drained slowly even if the monitor is turned off. If the monitor has not been charged for 7-10 days, the battery voltage will be low.

The factory-supplied battery is designed to last for 10 hours of normal operation (no alarm, no back light condition), for a new battery under the best condition. As the battery becomes older or is subject to adverse conditions (such as cold ambient temperature), the battery capacity will be reduced significantly.

2) Alkaline Battery Holder

An alkaline battery holder is supplied with each MiniRAE 2000. It accepts four AA size alkaline batteries and can be used in place of the Ni-MH or Ni-Cd battery pack to provide approximately 12-14 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Ni-Cd or Ni-MH battery pack.

To install the adapter, remove the cover of the battery compartment. Remove the Ni-Cd or Ni-MH battery pack from the battery compartment and replace with the alkaline battery adapter. Replace the battery compartment cover.

The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the monitor.

Note: The AA Alkaline battery adapter supplied by RAE Systems Inc. is intrinsically safe!

3) Water Trap Filter

The water trap filter is made of PTFE (Teflon®) membrane with a 0.45 micron pore size to prevent water from being sucked into the sensor manifold, which would cause extensive damage to the monitor. It will also remove any dust and other particles from entering the monitor and prolong the operating life of the sensor. To install the water trap, simply insert it to the front of the inlet tube of the MiniRAE 2000 monitor.

3.2 Optional Accessories

1) Dilution Fitting

The user may wish to install a dilution fitting on the inlet to dilute the gas samples. One application for a dilution fitting is to measure organic gas when the concentration exceeds the upper limit of the sensor range.

Make sure to set the dilution ratio in the programming mode (see Section 4.7.9) so that the correct gas reading will be displayed when the dilution fitting is used.

WARNING: To use a dilution fitting, the user must have the monitor located in a clean atmosphere outside the confined space and use a remote access probe or Tygon tubing to measure the gas concentration inside the confined space.

2) Calibration Adapter

The calibration adapter for the MiniRAE 2000 is a simple 6-inch Tygon tubing with a metal adapter on one end. During calibration, simply insert the metal adapter into the regular gas inlet probe of the MiniRAE 2000 and the tubing to the gas regulator on the gas bottle.

3) Calibration Regulator and Flow Controller

The Calibration Regulator and Flow controller is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the MiniRAE 2000 monitor during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a Demand-flow Regulator or a Tedlar gas bag may be used to match the pump flow precisely.

4) Organic Vapor Zeroing kit (Charcoal filter)

The Organic Vapor Zeroing Kit is used for filtering organic air contaminants that may affect the zero calibration reading. To use the Organic Vapor Zeroing Kit, simply connect the filter to the inlet port of the MiniRAE 2000.

3-6

PROGRAMMING

4.1 Programming Mode

The programming mode allows the users to change the setups in the monitor, calibrate the monitor, modify the sensor configuration and enter user information, etc. The programming mode has four menu items. Each menu item includes several sub-menus to perform additional programming functions. Appendix A shows a more detailed menu tree structure.

Programming Menu

- Calibrate/Select Gas?
- Change Alarm Limits?
- Change Datalog?
- Change Monitor Setup?

Once inside the programming mode, the LCD will display the first menu. Each subsequent menu item can be viewed by pressing the [N/-] repeatedly until the desired menu is displayed. To enter the sub-menu of a particular menu, press [Y/+], the sub-menu will be displayed.

Return to Operation mode: To exit the programming mode and return to operation, press the [MODE] key once at any of the programming menu displays.

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4. PROGRAMMING OF MINIRAE 2000

The MiniRAE 2000 Monitor is built with a microcomputer to provide programming flexibility. Authorized users can re-calibrate the monitor, change the alarm limits, change site ID, user ID, lamp type, and real time clock, etc.

Programming is menu-driven to provide intuitive end-user operation. The display shows the menu options and the key pad used for menu selection and data entry.

4-1

PROGRAMMING

4.2 Keys for Programming Mode

The three keys perform a different set of functions during the programming mode as summarized below.

Key	Function in Programming Mode
[MODE]:	Exit menu when pressed momentarily or exit data entry mode when pressed and held for 1 second
[Y/+]:	Increase alphanumerical value for data entry or confirm (yes) for a question
[N/-]:	Decrease alphanumerical value for data entry or deny (no) for a question

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4.3 Entering into Programming Mode

1. Turn on the MiniRAE 2000 monitor and wait for the "Ready.." message or the instantaneous reading display "0.0 ppm" message displayed.
2. Press and hold down both [N/-] and [MODE] keys for three seconds to enter programming mode. This delay is to prevent the user from entering programming mode by accident.
3. The first menu item "Calibrate/select Gas?" will be displayed.
4. Release both [MODE] and [N/-] keys simultaneously to start the programming mode
5. Press [N/-] key to scroll to the next menu item of the programming menu. Press [Y/+] key to select the displayed menu item.

The following Sections 4.4 - 4.7 describe the details of each menu options.

4.4 Calibrate and Select Gas

WARNINGS

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service for the first time.

For maximum safety, the accuracy of the MiniRAE 2000 should be checked by exposing it to known concentration calibration gas before each day's use.

In the first menu of the programming mode, the user can perform functions such as calibration of the MiniRAE 2000 Monitor, select default cal memories, and modify cal memories (see Table 4.4).

Table 4.4

Calibrate/Select Gas Sub-Menu
Fresh Air Cal?
Span Cal?
Select Cal Memory?
Change Span Value?
Modify Cal Memory?
Change Correction Factor?

Calibrating the MiniRAE 2000 monitor is a two-point process using "fresh air " and the standard reference gas (also known as span gas). First a "Fresh air" calibration, which contains no detectable VOC (0.0 ppm), is used to set the zero point for the sensor. Then a standard reference gas that contains a known concentration of a given gas is used to set the second point of reference.

Note: The span value must be set prior to calibrating for fresh air or span.

The user can store calibrations for up to 8 different measurement gases. The default gas selections are as follows:

- Cal Memory #0.....Isobutylene
- Cal Memory #1.....Hexane
- Cal Memory #2.....Xylene
- Cal Memory #3.....Benzene
- Cal Memory #4.....Styrene
- Cal Memory #5.....Toluene
- Cal Memory #6.....Vinyl Chloride
- Cal Memory #7.....Custom?

Memory #0 functions differently than the other 7 memories. For Memory #0, isobutylene is always the calibration gas. When the gas is changed in Memory #0 to one of 100 other preprogrammed chemicals or to a user-defined custom gas, a correction factor is applied to all the readings. During calibration, the unit requests isobutylene gas and displays the isobutylene concentration immediately following calibration, but when the unit is returned to the normal reading mode, it displays the selected gas and applies the correction factor.

The other 7 cal memories require the same calibration gas as the measurement gas. These memories may also be modified to a preprogrammed chemical or to a user-defined custom gas. In the gas library, only the gases that can be detected by the installed UV lamp will actually be displayed. Note that although the correction factor for the new gas will be displayed and can be modified, this factor is not applied when Memories #1-7 are

used. Therefore the factor will not affect the readings in these memories.

Once each of the memories has been calibrated, the user can switch between the calibrated gases by changing the cal memory without the need to recalibrate. Or the user can switch the measurement gas in Memory #0 and the appropriate correction factor will automatically be applied without the need to recalibrate. If the gas is changed in Memories #1-7, it is necessary to recalibrate.

To change a default gas from the list above to a library or custom gas, first go to Select Cal Memory (Section 4.4.3) and then proceed to Modify Cal Memory (Section 4.4.5) to enter the desired gas. If the desired compound does not appear in the preprogrammed library, the user can use the Custom_VOC entry in the library, or the name and correction factor of any of the existing compounds can be changed as described in Section 4.4.5. A list of some 300 correction factors is given in Technical Note 106, available at the website www.raesystems.com.

4.4.1 Fresh Air Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the MiniRAE 2000 to a "fresh" air source such as from a cylinder or Tedlar bag (option accessory). The "fresh" air is clean dry air without any organic impurities. If such an air cylinder is not available, any clean ambient air without detectable contaminant or a charcoal filter can be used.

1. The first sub-menu shows: "Fresh air Cal?"
2. Make sure that the MiniRAE 2000 is connected to one of the "fresh" air sources described above.
3. Press the [Y/+] key, the display shows "zero in progress" followed by "wait.." and a countdown timer.

After about 15 seconds pause, the display will show the message "update data... zeroed... reading = X.X ppm..." Press any key or wait about 20 seconds, the monitor will return back to "Fresh air Calibration?" submenu.

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4.4.2 Span Calibration

This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar Bag, or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the MiniRAE 2000 Monitor, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

Before executing a span calibration, make sure the span value has been set correctly (see next sub-menu).

1. Make sure the monitor is connected to one of the span gas sources described above.
2. Press the [Y/+] key at the "Span Cal?" to start the calibration. The display shows the gas name and the span value of the corresponding gas.
3. The display shows "Apply gas now!" Turn on the valve of the span gas supply.

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4. Display shows "wait... 30" with a count down timer showing the number of remaining seconds while the monitor performs the calibration.
5. To abort the calibration, press any key during the count down. The display shows "Aborted!" and return to "Span Cal?" sub-menu.
6. When the count down timer reaches 0, the display shows the calibrated value.
Note: The reading should be very close to the span gas value.
7. During calibration, the monitor waits for an increased signal before starting the countdown timer. If a minimal response is not obtained after 35 seconds, the monitor displays "No Gas!" Check the span gas valve is on and for lamp or sensor failure before trying again.
8. The calibration can be started manually by pressing any key while the "Apply gas now!" is displayed.
9. After a span calibration is completed, the display will show the message "Update Data Span Cal Done! Turn Off Gas."
10. Turn off the flow of gas. Disconnect the calibration adapter or Tedlar bag from the MiniRAE 2000 Monitor.
11. Press any key and it returns back to "Span Gas Cal?"

4-10

4.4.3 Select Cal Memory

This function allows the user to select one of eight different memories for gas calibration and measurement. For Memories #1-7, the calibration and measurement gas is the same and no correction factor is applied. For Memory #0, the calibration gas is always isobutylene and the measurement gas may be different, in which case the correction factor for that gas is automatically applied. The default gas selections are listed in Section 4.4

1. "Select Cal Memory?" is the third sub-menu item in the Calibration sub-menu. Pressing the [Y/+] key, the display will show "Gas =" gas name followed by "Mem # x?"
2. Press [N/-] to scroll through all the memory numbers and the gas selections respectively. Press [Y/+] to accept the displayed Cal Memory number.
3. After the [Y/+] key is pressed, the display shows "Save?" Press [Y/+] key to save and proceed. Press [N/-] to discard the entry and advance to the next sub-menu.
4. If the gas in a newly selected Cal Memory number is not calibrated, the display shows "CF= x.xx". A correction factor with the value "x.xx" will be applied.
5. If the gas of a newly selected cal memory number has been calibrated previously, the display shows "Last calibrated xx/xx/xx".

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4.4.4 Change Span Value

This function allows the user to change the span values of the calibration gases.

1. "Change Span Value?" is the fourth sub-menu item in the Calibration sub-menu
2. Press [Y/+], display shows the gas name and the span value. A cursor will blink at the first digit of the Span value. To modify the span gas value, go to Step 3. Otherwise, press and hold the [MODE] key for 1 second to accept the previously stored span gas value and move to the next sub-menu.
3. Starting from the left-most digit of the span gas value, use the [Y/+] or [N/-] key to change the digit value and press [MODE] key momentarily to advance to next digit. Repeat this process until all digits are entered. Press and hold the [MODE] for 1 second to exit.
4. The display shows "Save?" To accept the new value, press the [Y/+] key. Press the [N/-] key or the [MODE] key to discard the change and move to the next sub-menu.

4.4.5 Modify Cal Memory

If the current cal memory number selected is not memory 0, users will be prompted whether to modify the settings of the selected cal memory. Press [Y/+] to modify the cal memory and [N/-] to go to the next sub-menu.

Once [Y/+] is pressed the LCD display will show the current memory number, current Gas selected and prompt user for acceptance of current gas selected.

1. Press [N/-] to modify the gas selection if desired. Or press [Y/+] key to skip the change of gas selection, and proceed to the next sub-menu.
2. After pressing [N/-], display shows "Copy gas from library?" Press [Y/+] to accept or [N/-] for the next sub-menu, "Enter Custom gas?"
3. In the "Copy gas from library" sub-menu, use [Y/+] and [N/-] keys to scroll through the selections in the library. Press [MODE] key momentarily to select the gas. The display shows "Save?" Press [Y/+] to save or [N/-] to discard the changes and proceed to next sub-menu.
4. In the Custom gas sub-menu, the user can enter the gas name. Press the [Y/+] or [N/-] key to cycle through all 26 letters and 10 numerals. Press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all digits (up to 8 digits) of the custom gas name is entered.

Press and hold the [MODE] key for 1 second to exit the name entry mode. The display will show "Save?" Press [Y/+] to save the entry, or [N/-] to discard the changes.

4.4.6 Change Correction Factor

This function allows the user to change the Correction Factor of the standard calibration gas (only for Cal Memory #0).

1. "Change Correction Factor?" is the sixth sub-menu in the Calibration sub-menu.
2. Press [Y/+] key. Display shows the gas name, then the correction factor.

A cursor blinks at the left-most digit of the correction factor. If user wants to modify the correction factor, go to Step 3. Otherwise, press and hold the [MODE] key for 1 second to accept the previously stored correction factor value and return to the first sub-menu of the calibrate/select gas menu.

3. Starting from the left-most digit of the correction factor, use [Y/+] or [N/-] key to change the digit value and press [MODE] key momentarily to advance to the next digit, the cursor will move to the next digit to the right. Repeat this process until all digits are entered. Press and hold the [MODE] for 1 second to exit.
4. The display shows "Save?" To confirm the new value, press [Y/+] to accept the change. Press [N/-] or [MODE] to discard the change and return to the first sub-menu, Calibrate and Select Gas.

4.5 Change Alarm Limits

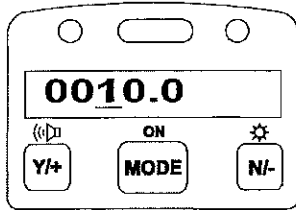
In this menu, the user can change the high and low alarm limits, the STEL limit and the TWA limit (see Table 4.5 below). Press the [Y/+] key and the display shows the current gas selected followed by the first sub-menu item below.

Table 4.5

Alarm Limit Sub-Menu
Change High Alarm limit?
Change Low Alarm limit?
Change STEL limit?
Change TWA limit?

1. Scroll through the Alarm Limit sub-menu using the [N/-] key until the display shows the desired limit to be changed, e.g., "High limit?", "STEL limit?", etc.

- Press the [Y/+] key to select the desired limit and the display shows a flashing cursor on the left-most digit of the previously stored alarm limit.



- To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to its right. Repeat this process until the new limit value is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
- If there is any change to the existing value, the display shows "Save?" Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.5.1 Change Low Alarm Limit

The second sub-menu item in the Alarm Limit sub-menu allows the user to change the Low Alarm limit. The LCD displays "Low limit?" To change Low Alarm limit, press [Y/+] key, or Press [N/-] key advance to next sub-menu in Table 4.5.

- Press [Y/+] and the display will show a flashing cursor on the left-most digit of the previously stored Low alarm limit.
- To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to its right. Repeat this process until the new limit values is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
- If there is any change to the existing value, the display shows "Save?" Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.5.2 Change STEL Limit

This sub-menu item allows the user to change the STEL limit. The display shows "STEL limit?"

- Press the [Y/+] key and the display will show a flashing cursor on the left-most digit of the previously stored STEL limit.
- To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new limit values is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
- If there is any change to the existing value, the display shows "Save?" Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.5.3 Change TWA Limit

This sub-menu item allows the user to change the TWA limit. The LCD displays "TWA limit?"

- Press [Y/+] and the display will show a flashing cursor on the left-most digit of the previously stored TWA limit.
- To modify this limit value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new limit values is entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
- If there is any change to the existing value, the display shows "Save?" Press [Y/+] to accept the new value and move to the next sub-menu. Press [N/-] to discard the changes and move to the next sub-menu.

4.6 Change Datalog

The MiniRAE 2000 monitor calculates and stores the concentration and ID of each sample taken. In the datalog sub-menu, a user can perform the tasks and functions shown below.

Datalog Sub-Menu

- Reset Peak/Minimum?
- Clear Data?
- Change Data Period?
- Change Average Type?

4.6.1 Reset Peak

This function will reset the peak and minimum stored in the data memory. Note: this function will not clear the STEL or TWA data.

1. "Reset Peak?" is the first sub-menu item in the Datalog sub-menu (Table 4.6).
2. Press the [Y/+] key to reset the Peak/Minimum Values. The display shows "Are You Sure?"
3. Pressing the [Y/+] key again will reset the values. The display shows "Peak/Minimum Cleared" and moves to the next sub-menu.
4. Press the [N/-] or [MODE] key to exit without resetting the values and move to the next sub-menu.

4.6.2 Clear Data

This function will erase all data stored in the non-volatile datalog memory. Note: This function does not change STEL, TWA, Peak, Minimum and run time values, which are stored in the regular data memory.

1. "Clear Data?" is the third sub-menu item in the Datalog sub-menu.
2. Press the [Y/+] key to clear the datalog memory. The display shows "Are you sure?"
3. Press the [Y/+] key again to confirm erasure of all the datalog memory.
4. Press the [N/-] or [MODE] key to exit without clearing the datalog memory and move to the next datalog sub-menu.

4.6.3 Change Data Period

The datalog period can be programmed from 1 to 3,600 seconds (1 hour).

1. "Change Data Period?" is the fifth sub-menu item in the Datalog sub-menu.
2. Press the [Y/+] key and the display shows "Datalog Period = XXXX" with the left-most digit flashing, where "XXXX" is the previously stored data log period.
4. To modify this period, starting from the left-most digit, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 4 digits of the new period are entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
5. If there is any change to the existing value, the display will show "Save?" Press [Y/+] to accept the new value or [N/-] to discard the changes and move to the next sub-menu.

4.6.4 Change Average Type

The user can select either an 8-hour Time Weighted Average (TWA) or a running Average. The running average is simply the average of all instantaneous (1-second) readings since the measurement was started. This average may increase or decrease with time depending on the readings. The TWA is a cumulative value used to estimate the fraction of the 8-hour limit to which the user has been exposed since the start of the measurement. This value can only increase or remain constant, never decrease. Refer to Technical Note 119 for more information on how TWA is calculated.

1. "Change Average Type?" is the sixth sub-menu in the Datalog sub-menu.
2. Press the [Y/+] key to enter the function.
3. The display will show "Running Average?" or "Time Weighted Average?" depending on the current average type.
4. Press [N/-] key to toggle between the average types. Press [Y/+] key to select the displayed average type.
5. If there is any change to the existing setting, the display shows "Save?" Press [Y/+] to save the change. Press [N/-] or [MODE] to discard the change and return to the first sub-menu.

4.7 Change Monitor Setup

Several monitor specific variables can be changed in this menu. The following is a list of configuration data that can be modified by the user.

Monitor Setup Sub-Menu	Diagnostic Mode
Change Operation Mode?	"
Change Site ID?	Change Unit ID?
Change User ID?	Change Host ID?
Change Alarm Mode?	"
Change User Mode?	"
Change Date?	"
Change Time?	"
Change Lamp?	"
Change Pump Duty Cycle?	"
Change Unit?	"
Change Dilution Ratio?	"
Change Output?	"
Change DAC Range?	"
Set Temperature Unit?	"

4.7.1 Change Operation Mode

MiniRAE 2000 supports two operation modes: Survey and Hygiene mode.

Survey mode: Manual start/stop of measurements and display of certain exposure values.

Hygiene mode: Automatic measurements, running and datalogging continuously and calculates additional exposure values.

1. "Change Op Mode?" is the first sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key and the display shows the current user mode: "Op Mode = *current mode*?"
3. Press the [Y/+] key to accept the currently displayed operation (Op) mode. Press [N/-] to toggle to the other operation mode. Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. When changing Op mode from Hygiene to Survey, the display shows the additional message "Warning! Exit Hygiene?" to prevent accidental exit from Hygiene mode. Press the [Y/+] key to acknowledge.
5. If there is any change to the existing setting, the display will show "Save?" Press the [Y/+] key to accept or the [N/-] key to discard and move to the next sub-menu.

Note: If a new Op Mode is saved, the display shows "Op Mode changed!!" when exiting the programming mode.

4.7.2 Change Site ID

The user can enter an 8-digit alphanumeric site ID in the programming mode. This site ID will be included in the datalog report.

1. "Change Site ID?" is the second sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key and the display shows the current site ID: "Site ID = xxxxxxxx" with the left most digit flashing.
3. Press the [Y/+] or [N/-] key to cycle through all 26 letters and 10 numerals. Press [MODE] momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 8 digits of the new site ID are entered.
4. Press and hold the [MODE] key for 1 second to exit the data entry mode.
5. If there is any change to the existing site ID, the display shows "Save?" Press the [Y/+] key to accept the new site ID. Press the [N/-] key to discard the change and move to the next sub-menu.

4.7.3 Change User ID

The user can enter an 8-digit alphanumeric user ID in the programming mode. This user ID will be included in the datalog report.

1. "Change User ID?" is the third sub-menu item the Monitor Setup menu.
2. Press the [Y/+] key and the display shows the current user ID: "User ID = xxxxxxxx" with the left most digit flashing.
3. Press the [Y/+] or [N/-] key to cycle through all 26 letters and 10 numerals. Press [MODE] momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 8 digits of the new user ID are entered.
4. Press and hold the [MODE] key for 1 second to exit the data entry mode.
5. If there is any change to the existing user ID, the display shows "Save?" Press the [Y/+] key to accept the new user ID. Or press the [N/-] key to discard the changes and move to the next sub-menu.

4.7.4 Change Alarm Mode?

There are two different alarm modes: **Latched** and **Automatic Reset (Auto Reset)** in the MiniRAE 2000 that can be selected from the programming menu.

1. "Change Alarm Mode?" is the fourth sub-menu item in the Monitor Setup menu.
2. Press the [Y/+] key; the display shows the current alarm mode.
3. Press the [Y/+] key to accept the currently displayed alarm mode. Press [N/-] key to toggle to the other alarm mode. Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing setting, the display will show "Save?" Press [Y/+] to save the change. Press [N/-] or [MODE] to discard the change and move to the next sub-menu.

4.7.5 Change User Mode

There are two different user modes: **Display** and **Program** that can be selected from the programming menu.

1. "Change User Mode?" is the fifth sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the [Y/+] key; the display shows the current user mode selected.
3. Press the [Y/+] key to accept the currently displayed user mode. Press [N/-] key to toggle to the alternate user modes. Press [MODE] to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing selection, the display shows messages "Program change" and "Are you sure?" Press [Y/+] to confirm the change or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

CAUTION: If the user mode is changed to **Display** mode, the user can no longer enter the programming mode. Therefore, the user can not change the user mode back to **Program** mode in normal mode.

To restore the user mode back to **Program** mode, turn the unit off and back on in Diagnostic Mode. Next enter Program mode by holding the [MODE] and [N/-] keys for three seconds. Enter the password at the prompt (the default is 0000). Once program mode is entered, go to the "Change Monitor Setup" / "Change User Mode" and change the mode back to **Program**.

An alternative way to change Display mode back to Program mode is through the PC and the ProRAE-Suite software.

4.7.6 Change Date

The MiniRAE 2000 monitor is equipped with a real time clock (RTC). The user can enter the correct date and time (see 4.7.7) for the real time clock.

1. "Change Date?" is the sixth sub-menu item in the Monitor Setup menu.
2. Press [Y/+] and the display shows the current date "mm / dd / yy" with the left most digit of the date flashing.
3. To modify this value, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new date and time values are entered. Press and hold the [MODE] key for 1 second to exit data entry mode.
4. If there is any change to the existing value, the display shows "Save?" Press [Y/+] to confirm the new value or press [N/-] or [MODE] to discard the changes and move to the next sub-menu.

6.3 Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

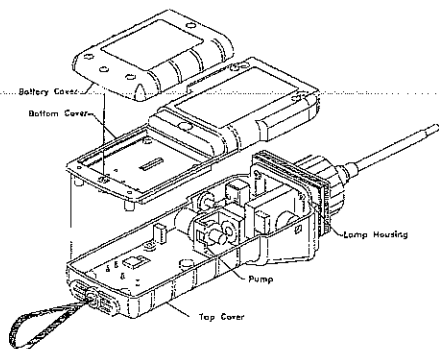


Figure 7-3 Sampling Pump

6-7

6.4 Turning on the UV Lamp

The UV lamp is made of a glass envelope and a UV window (salt crystal) on one end of the envelope. The inside of the lamp is filled with low pressure gases. To turn on the lamp, a high voltage electric field is applied from the outside of the glass envelope. The molecules inside the lamp are ionized and produce a glow discharge that generates the UV light. The MiniRAE 2000 has a built-in sensing mechanism to monitor the status of the UV lamp and display a "Lamp" error message if it is not on.

If the UV lamp has not been used for a long period of time (> 1 month) or is cold, it may become slightly harder to turn on. If such a condition occurs, the "Lamp" message will appear in the monitor display during the power on sequence. This phenomenon is more significant in 0.25" UV lamps used in ToxiRAE and MultiRAE Plus products, because of the relatively small lamp size. To solve this problem, simply turn on and off the monitor a few times and the lamp should turn on. After the UV lamp is turned on for the first time, it should be easier to turn on the UV lamp next time.

It is possible that the UV lamp is actually on when the lamp error message appears. This is because when the lamp becomes old, the internal threshold level to detect lamp failure may have shifted and cause a false alarm. To eliminate such possibility, simply check to see the UV lamp is actually on. This can be done easily by removing the sensor cap and observing the glow light of the UV lamp in a dark place. The user can also feed the monitor with calibration gas and observe if the sensor reading changes. If the reading changes significantly with the gas, the UV lamp is actually on.

A possible failure mechanism for the UV lamp is a leak developed along the seal of the glass envelope. When such condition occurs, the lamp will become very hard or impossible to turn on and will need to be replaced.

6-9

Pump Replacement

1. Turn off the MiniRAE 2000 power.
2. Open the battery cover, remove the battery pack, and carefully unscrew the six screws to open the bottom cover.
3. Unplug the pump from the PCB. Unscrew the two screws that hold the pump assembly to the PCB. Disconnect the Tygon tubing that connects the pump to the gas inlet port and gas outlet port.
4. Insert a new pump assembly. Connect the Tygon tubing to the gas inlet port. Plug the pump connector back into the PCB and screw down the pump assembly to the board.
5. Replace the bottom cover and tighten the six screws. Reconnect the battery pack. Replace the battery pack and its cover.

6-8

7. TROUBLESHOOTING

To aid the user in diagnosing the monitor, a special diagnostic mode can be used displays critical, low level parameters. Section 7.1 describes the operation of the diagnostic mode. Section 7.2 summarizes the frequently encountered problems and suggested solutions. By turning on the MiniRAE 2000 monitor in diagnostic mode and by using the troubleshooting table in Section 7.2, the user can usually correct the problem without having to return the monitor for repair.

WARNING

This function should be used by qualified personnel only! The diagnostic mode allows the user to set several low-level parameters that are very critical to the operation of the monitor. Extra care should be taken when setting these parameters. If the user is not familiar with the function of these parameters and sets them incorrectly, it may cause the monitor to shut down or malfunction.

7-1

7.1 Troubleshooting Table

Problem	Possible Reasons & Solutions
Cannot turn on power after charging the battery	Reasons: Discharged battery. Defective battery. Microcomputer hang-up. Solutions: Charge or replace battery. Disconnect, then connect battery to reset computer.
No LCD back light	Reasons: Trigger level too low, the current mode is not user mode, and the mode does not support automatic turn on back light. Solutions: Adjust trigger level. Verify the back light can be turned on in user mode. Call authorized service center.
Lost password	Solutions: Call Technical Support at +1.408.752.0723 or +1.888.723.4800
Reading abnormally High	Reasons: Dirty sensor module. Dirty water trap filter. Excessive moisture and water condensation. Solutions: Clean sensor module and lamp housing. Replace water trap filter. Blow dry the sensor module.
Buzzer Inoperative	Reasons: Bad buzzer. Solutions: Call authorized service center.

7-2

Inlet flow too low	Reasons: Pump diaphragm damaged or has debris. Flow path leaks. Solutions: Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Replace pump or diaphragm.
"Lamp" message during operation	Reasons: Lamp drive circuit. Weak or defective PID lamp, defective. Solutions: Turn the unit off and back on. Replace UV lamp
Full scale measurement in humid environment	Reasons: Dirty or wet sensor. Solutions: Clean and dry sensor and lamp housing. Adjust sensor fingers to ensure not touching Teflon. Use water trap filter.
Reading abnormally low	Reasons: Incorrect calibration. Low sensitivity to the specific gas. Weak or dirty lamp. Air leakage. Solutions: Calibrate the monitor. Replace sensor. Clean or replace lamp. Check air leakage.

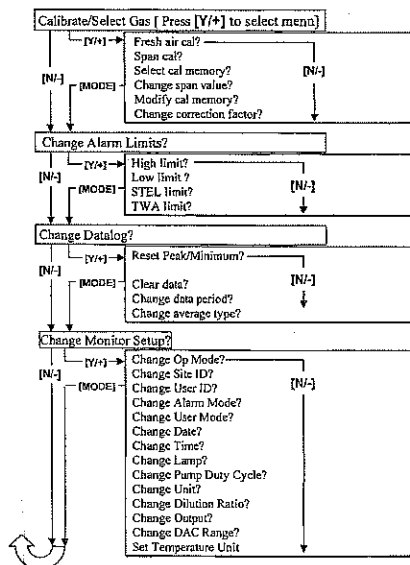
7-3

APPENDIX A

APPENDIX A. QUICK REFERENCE GUIDE

Press [N/-] and [MODE], simultaneously, for 3 seconds, to enter Programming Mode. Press [MODE] to return to Survey Mode.

PROGRAMMING MODE



A-1

RAE Systems, Inc. Contact Information

Main Office: 3775 N. First St.
San Jose, CA 95134-1708
USA
Telephone: 408-952-8200
Fax: 408-952-8480
Instrument Sales: 877-723-2878
Email: RaeSales@raesystems.com
Website: www.raesystems.com
Technical Service: 888-723-4800
Tech@raesystems.com

Attachment 3

Special Note

If the monitor needs to be serviced, contact either:

1. The RAE Systems distributor from whom the monitor was purchased; they will return the monitor on your behalf.
2. The RAE Systems Technical Service Department. Before returning the monitor for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the monitor is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

APPLICATION NOTE

RAE SYSTEMS PID TRAINING OUTLINE

What is a PID?

A Photo-Ionization Detector measures VOCs and other toxic gases in low concentrations from ppb (parts per billion) up to 10,000 ppm (parts per million or 1% by volume). A PID is a very sensitive broad-spectrum monitor, like a "low-level LEL monitor. RAE Systems' improvements in PID technology have miniaturized and "ruggedized" PIDs allowing them to provide new and innovative monitoring solutions for:

- **LEL Measurements:** PIDs provide a more reliable means of measuring LEL in applications like Jet Fuel and Turpentine vapors (ref. AP-200, 204, 219)
- **Ammonia:** (ref. AP-201)
- **HazMat:** Hazardous Materials Response (ref. AP-203)
- **Heat Transfer Fluids:** (ref. AP-205)
- **Arson:** (ref. AP-207)
- **Industrial Hygiene:** to help determine chemical exposures (ref. AP-211)
- **Indoor Air Quality:** (ref. AP-212)
- **Environmental:** residual soil, air, or water contamination (ref. AP-214)
- **Safety:** Confined Space Entry (ref. AP-211)
- **Maintenance:** Leak detection and fugitive emissions monitoring (ref. AP-214)
- **Domestic Preparedness:** (ref. AP-216)
- **Clean Labs:** (ref. AP-220)

How does a PID Work?

A Photo Ionization Detector (PID) uses an Ultraviolet (UV) light source (Photo[®] light) to break down chemicals to positive and negative ions (ionization) that can easily be counted with a Detector. Ionization occurs when a molecule absorbs the high energy UV light, which excites the molecule and results in the temporary loss of a negatively charged electron and the formation of positively charged ion. The gas becomes electrically

charged. In the Detector these charged particles produce a current that is then amplified and displayed on the meter as "ppm" (parts per million) or even in "ppb" (parts per billion). The ions quickly recombine after the electrodes in the detector to "reform" their original molecule. PIDs are non-destructive; they do not "burn" or permanently alter the sample gas, which allows them to be used for sample gathering.

What does a PID Measure?

All elements and chemicals can be ionized, but they differ in the amount of energy they require. The energy required to displace an electron and "ionize" a compound is called its Ionization Potential (IP), measured in electron volts (eV). The light energy emitted by an UV lamp is also measured in eV. If the IP of the sample gas is less than the eV output of the lamp, then the sample gas will be ionized.

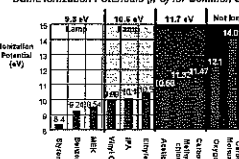
PID Operation Simplified

While this sounds complicated, it is very simply explained. A PID uses a lamp to break down gases and vapors.

- If the "wattage" of a gas or vapor is less than the "wattage" of the PID lamp, then the PID can "see" the gas or vapor.
- If the "wattage" of the gas or vapor is greater than that of the PID lamp the PID cannot "see" the vapor.

Therefore, a PID with a "75 watt" lamp could see a "50 watt" gas but could not "see" a "85 watt" gas. "Wattage" for PIDs is expressed in "Electron Volts" or eV and is known as the Ionization Potential (IP) for a particular gas or vapor. Ionization Potential is a measure of the bond strength of a gas, or how well it is "built."

Same Ionization Potentials (IPs) for Common Chemicals



Benzene has an IP of 9.24 eV and can be seen by a "standard" 10.6 eV lamp. Methylene Chloride has an IP of 11.32 eV and can only be seen by an 11.7 eV lamp. Carbon Monoxide has an IP of 14.01 eV and cannot be ionized by a PID lamp.

IPs can be found in the NIOSH Pocket Guide, PID manufacturer literature or in many chemical texts. RAE Systems uses a NIST (National Institute of Science & Technology) Database containing over 11,000 compounds to determine IPs of new compounds to be measured (please reference RAE Systems publication TN-105 "Correction Factors, Ionization Potentials and Calibration Characteristics").

What Does a PID Measure?

The largest group of compounds measured by a PID are the Organics: compounds containing Carbon (C) atoms. These include:

- **Aromatics:** compounds containing a benzene ring including benzene, toluene, ethyl benzene and xylene.
 - **Ketones & Aldehydes:** compounds with a C=O bond including acetone, methyl ethyl ketone (MEK) and acetaldehyde.
 - **Amines & Amides:** Carbon compounds containing nitrogen, like diethylamine.
 - **Chlorinated hydrocarbons:** trichloroethylene (TCE), perchloroethylene (PERC)
 - **Sulfur compounds:** mercaptans, sulfides
 - **Unsaturated hydrocarbons:** like butadiene and isobutylene
 - **Alcohol-like isopropanol (IPA) and ethanol**
 - **Saturated hydrocarbons:** like butane and octane
- In addition to organic compounds, PIDs can be used to measure some inorganics. These are compounds without carbon and include:
- Ammonia
 - Semiconductor gases: Arsine, Phosphine
 - Hydrogen sulfide
 - Nitric Oxide
 - Bromine and Iodine

What PIDs Do Not Measure

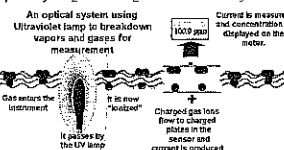
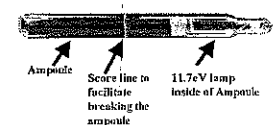
- Radiation
- Air (N₂, O₂, CO₂, H₂O)
- Common Toxics (CO, HCN, SO₂)
- Natural Gas (Methane, Ethane)
- Acid Gases (HCl, HF, HNO₃)
- Others: Freons, Ozone (O₃), Hydrogen peroxide
- Non-volatiles: PCBs, Greases

9.8 & 10.6 eV versus 11.7 eV PID Lamps

At first glance, it may appear that to measure the broadest range of gases with a PID an 11.7 eV lamp should be used instead of a 10.6 eV lamp. However, the following must be considered:

- 9.8 and 10.6 eV are more specific; lower IP means that they "see" fewer chemicals.

- 9.8 and 10.6 last a few years; about the same lifetime and cost as a CO sensor.
- 9.8 and 10.6 eV are more sensitive; 11.7 eV lamps provide lower resolution: the lithium fluoride crystal in the 11.7 eV lamp does not allow as much light energy through, effectively making the 11.7 eV lamp "dimmer" than the 10.6 eV lamp. Less energy transmitted means less ionization taking place, which reduces the potential resolution. Essentially a 10.6 eV lamp is 10 times more powerful than an 11.7 eV lamp. Therefore, for best accuracy, it is not recommended to use 11.7 eV lamps for applications requiring very high sensitivity. Examples include formaldehyde which has an OSHA TWA of just 0.75 ppm.
- 11.7 eV have a shorter life than 9.8 or 10.6. All 11.7 eV lamps (including those made by RAE's competitors) have a window made of Lithium Fluoride to transmit the high energy UV light. Lithium Fluoride is harder to seal to the lamp glass, is very hygroscopic and readily absorbs water from air even when not in use. This causes the window to swell and decreases the amount of light transmitted through the window. Lithium Fluoride also is degraded by UV light, the more the instrument is used the greater the damage. These factors contribute to a shortened lamp life. While a 10.6 eV lamp can last 24-36 months, an 11.7 eV lamp will typically last only 2-6 months.
- 11.7 eV bulbs should only be used when compounds with IPs over 10.6 eV are expected. Examples include methylene chloride, chloroform, and carbon tetrachloride.
- **Least expensive and easiest to change 11.7 eV lamp:** While RAE Systems' 11.7 eV lamp is the least expensive in the PID market, with some 11.7 eV lamps costing as much as \$500, they still are more expensive than a 10.6 eV lamp. Unlike some PIDs that require expensive conversion kits, RAE Systems' 11.7 eV lamps drop right into our instruments. No modifications are necessary. You change the lamp, recalibrate and measure.
- **Long Term Storage of 11.7 Lamps:** As a solution to the problem of short lifetime for 11.7 lamps, RAE often them packaged in sealed glass ampoules. The gas in the ampoule is the same as in the lamp. The ampoule effectively packages a new lamp in a lamp. When the 11.7 lamp is required, the ampoule is broken, the lamp removed and inserted into the PID.



Distributed by AFC International Inc

PID Training Outline page 2

This ampoule is only available for the 1/2" lamps used in the MultiRAE and ToxiRAE PIDs.

- **Extending 11.7eV Lamp Life:** 11.7eV lamp life can be extended if the lamp is stored in a desiccant environment (in or out of the PID) between uses. This can simply be a container containing "silica gel" drying packs like those that ship with electronic and camera equipment. It is not recommended to store MultiRAEs in a desiccant environment because this will decrease the life of its electrochemical sensors.

Selectivity & Sensitivity

A PID is a very sensitive monitor that can accurately measure gases and vapors in low ppm or even ppb levels. However, the PID is not a selective monitor. It has very little ability to differentiate between chemicals. To visualize this, let's compare the PID to a ruler. A ruler is a sensitive and accurate means of measuring the width of a sheet of paper. But it cannot tell the difference between



gray and white paper. Therefore, if one wants to know the width of the gray sheet of paper, that person must first select the proper sheet of paper before measuring with the ruler. We use our head to determine which sheet of paper is gray.

The PID is similar to the ruler. It can tell us how much of a gas or vapor is present, but we must use our head to determine the exact gas or vapor present. When approaching an unknown chemical release, the PID is set to its calibration gas of isobutylene. Once the chemical is identified by means of placard, manifest, waybill or other means, the PID sensitivity can be adjusted to that chemical so that it reads in an accurate scale. For example, if we calibrate on isobutylene and happen to measure a toluene leak of 1 ppm the PID will display 2 ppm because it is twice as sensitive to toluene as it is to isobutylene. Once we have identified the leak as toluene, then the PID scale can be set to a toluene Correction Factor and the PID will accurately read 1 ppm if exposed to 1 ppm of toluene.

Remember that we use our head for "selectivity" and the PID "sensitivity." No Correction Factor is used until a compound is identified.

What's a Correction Factor?

Correction Factors (CF, also known as Response Factors) are a powerful tool in the use of PIDs. They are a measure of PID sensitivity to a particular gas. CFs permit calibration on one gas while directly reading the concentration of another, eliminating the need for multiple calibration gases. PID manufacturers determine Correction Factors by measuring a PID's response to a

known concentration of target gas (Ref. TN-120 "Measuring Correction Factors for Volatile Compounds with PIDs"). Correction Factors tend to be instrument and/or manufacturer specific so it is best to use the CFs from the manufacturer of the PID. Therefore, it may be best to choose a PID manufacturer with the largest listing of CFs. RAE Systems has the largest list of Correction Factors available for PIDs (ref. TN-106). However, while correction factors are convenient, it is always best to calibrate on the gas/vapor of interest for the highest measurement accuracy.

CF Measures Sensitivity

Correction Factors are scaling factors used to adjust the sensitivity of the PID to directly measure a particular gas compared to the calibration gas. The lower the Correction Factor (CF), the more sensitive the PID is as a gas or vapor. The following example uses CFs from a RAE Systems 10.6eV lamp:

- Toluene's CF is 0.5 so the PID is very sensitive to Toluene
- Ammonia's CF is 9.7 so PID is less sensitive to Ammonia

The PID is approximately 19 times more sensitive to Toluene as it is to Ammonia ($9.7/0.5=19.4$).

Guidelines for using Correction Factors

1. If a chemical is very toxic then if the PID is going to be used to measure it the PID should be very sensitive to that chemical. Therefore, if the chemical has an exposure limit of 10 ppm or less, a PID is an appropriate tool for personal safety decisions if the chemical's CF is less than 1.0 (e.g., Benzene has an exposure limit of 1 ppm and a CF of 0.5).
2. If a chemical is not extremely toxic, then the PID doesn't need to be as sensitive to it. Therefore, if the chemical has an exposure limit of over 10 ppm, a PID is an appropriate tool for personal safety decisions if the chemical's CF is less than 10. (e.g., ammonia has an exposure limit of 25 ppm and a CF of 9.7).
3. If the chemical's CF is greater than 10 PIDs are still appropriate as gross leak detectors (e.g., ethylene oxide has a CF of 13 with a 10.6 lamp) and are only appropriate for personal safety decisions for chemicals with very high exposure limits.

Microprocessor PIDs, like the MiniRAE 2000 and proRAE, can automatically store and apply over 100 CFs.

CF Example: Toluene

- If PID reads 100 ppm of isobutylene units in a Toluene atmosphere
- Then the actual concentration is 50 ppm Toluene units

$$0.5_{CF} \times 100 \text{ ppm}_{IB} = 50 \text{ ppm}_{Toluene}$$

CF Example: Ammonia

- If PID reads 100 ppm of isobutylene units in an Ammonia atmosphere
- Then the actual concentration is 970 ppm Ammonia units

$$9.7_{CF} \times 100 \text{ ppm}_{IB} = 970 \text{ ppm}_{Ammonia}$$

How to Determine if a PID can Measure a Particular Gas

1. Is the IP of the gas less than the eV output of the lamp?
 - Yes: go to step 2.
 - No: Select a higher energy lamp. If none available, then the PID cannot measure that gas.
 - Don't Know: Most PID manufacturers can help.
2. Is the CF less than 10?
 - Yes: a PID is an appropriate way of measuring that gas.
 - No: a PID is not an accurate means of measuring that gas, but it could still be a good way of gross measurement like leak detection.

Don't Know: Call RAE at 877-723-2878.

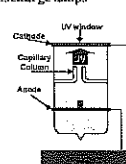
Why Calibrate with Isobutylene?

Isobutylene has been used to calibrate PIDs because its responsiveness is about midpoint in the range of sensitivity of PIDs. It is relatively easy to obtain and is non-toxic and non-flammable at the low concentrations used for calibration. For years PIDs were calibrated with benzene, but because of its carcinogenic properties benzene calibrations have been phased out. While PIDs are typically calibrated with isobutylene, they can be calibrated with any ionizable gas. For example, if a PID is to be used to measure only Vinyl Chloride, the PID can be calibrated directly with a known concentration of Vinyl Chloride.

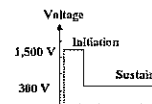
How Has RAE Advanced PID Lamps?

Competitor's Electrode Discharge lamps

A high energy electric current is conducted to a gas mixture via electrodes. The electrodes directly excite the gas mixture to produce light. A form of Vacuum (or Radio) tube these "valve electronic" devices have a number of issues.



- **Internal Contamination:** Electrode discharge lamps suffer from eroding electrodes that deposit on the lamp and reduce lamp output. We see this on fluorescent tubes when the ends darken as the lamp ages. While a 10% drop in light output is not detectable by the human eye, it can severely affect instrument readings and requiring more frequent calibration and ultimately reducing lamp life.
- **Metal to glass interfaces prone to failure:** We often see incandescent lightbulbs in too tight and they break loose from their base. This is a good example of metal to glass interface failure. It is difficult to bond glass to metal, and every metal to glass interface is a potential failure point. Like incandescent lightbulbs, metal to glass interfaces in an electrode discharge lamps are a potential failure points.
- **High power draw:** Electrode Discharge lamps have a high power draw compared to electrodeless discharge lamps. These several watt lamps waste energy as heat, requiring large batteries and are not as easy to use or carry.
- **High RFI:** We often get a burn on our personal radios when working near fluorescent lights. Electrode discharge lamps suffer from the same high RFI problem.



Competitors RF Excited Lamp

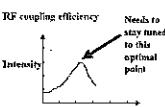
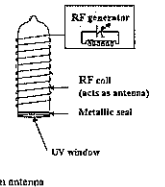
The electrodeless lamp is put into a coil of wire and is subjected to high frequency excitation energy (12-14 MHz) to generate a glow discharge in the lamp.

High Power Consumption

- **Subject to RFI:** High frequency excitation energy is effected by radios & power lines because Radio Frequency (RF) coil can act as an antenna

Higher Maintenance:

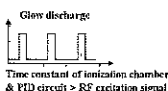
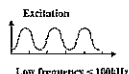
RF coupling efficiency requires perfectly tuned driving circuit. These complex circuits require constant tuning.



Advantages of RAE's Electrodeless Lamp

The RAE lamp is put into a low frequency RF field which indirectly excites the gas in it to glow. This is like using a microwave oven to cook food. Both the lamp and the food are excited to radiate (heat for the food, light for the lamp) by an external field.

- **Extremely low power draw:** RAE's Electrodeless Discharge lamps have an extremely low power draw.



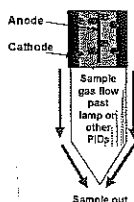
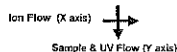
Resulting in a cool lamp and small batteries. Low power draw is a key factor in decreasing the size of RAE PIDs.

- **No internal contamination:** Electrodeless discharge lamps are externally excited and have no metal in them to damage, erode or migrate.
- **Extremely rugged:** Because they reduce or eliminate metal to glass interfaces electrodeless discharge lamps are extremely rugged. RAE Systems has totally eliminated all metal-glass interfaces in their 10.6 eV lamp. The magnesium fluoride crystal is welded to the lamp's glass.
- **Virtually no RFI or EMI:** RAE lamps are powered by a low-frequency electrical field. Compared with electrode discharge lamps, this method virtually eliminates Radio Frequency Interference (RFI).

How has RAE Systems Advanced PID Sensors?

Competitors Axial Flow Sensor

Sample enters a large sensor chamber with central anode and cathode surrounding it like a drum. The sample stream is directed directly at the lamp (axial flow).

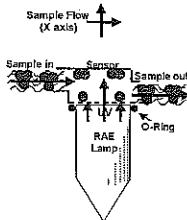


- **Slower Response Time:** sensor has large sample volume and thus requires a high bias voltage resulting in high power demand and big batteries.
- **Slower Recovery Time:** more volume to clear of sample

- **Greater Humidity affects:** Light has further to travel so moisture can "block" more light reducing PID response.
- **More lamp cleaning:** Sample & contaminants are directed to lamp face resulting in the need for frequent lamp cleanings.

Advantages of RAE's "2-D" Sensor

In the two dimensional or "2-D" sensor the sample is drawn across the lamp in a laminar manner rather than at the lamp in an axial manner. This is the first of the two dimensions and in the accompanying diagram flow is the X axis. The light comes up from the UV lamp at a 90 degree angle and is in parallel with the ion flow in the Y-axis of the accompanying diagram. Together they form the second dimension. This sensor is used in the MiniRAE, MiniRAE Plus, MultiRAE and ToxiRAE PIDs. The "2-D" sensor has a very small sensor chamber volume with lower bias voltage and less power requirements.



- **Fast Response:** Placing the sensor directly on top of the lamp minimizes the sample chamber volume and with the O-Ring seal provides nearly instantaneous response times as good as less than 3 sec. to 90% to 2000 ppm. This extremely fast response means more accurate and quicker leak or "hot spot" detection. To demonstrate this benefit of the MiniRAE, take a non-water-based marking pen like a "Sharpie" or a white-board marker and make a small line on a piece of paper. The MiniRAE will easily "find" this line in seconds.
- **Fast recovery:** Because the sample flow travels across rather than directly towards the lamp face, the top of the lamp chamber can be sealed with an O-Ring. This helps to decrease response and recovery times of RAE PIDs because it prevents sample gas from

accumulating around the lamp. Fast recovery means that the reading quickly returns to zero. Fast recovery between samples means that multiple sampling (like headspace samples) proceeds much faster than with any other PID. Fast recovery also provides for succinct detection of vapor leaks.

- **Low humidity response:** Laminar flow and placing the sensor on top of the lamp face maximizes the exposure of the gas stream to UV light. This drastically reduces humidity and non-ionizing gas interference in RAE



PIDs: Humidity molecules absorb UV like in much the same way the fog absorbs light from your car headlights when you drive on a foggy day. Because of this, you drive slower on foggy days because you can only see things that are close to your headlights. By keeping the sensor and the sample gas close to the UV light source (like the "short lightpath" in the accompanying diagram), RAE PID sensors allow the UV light to get to the sample gas before the water molecules can absorb or diffuse the UV light. The extremely fast response of the MiniRAE even allows users to add an external GoreTex™ membrane (water trap) to prevent condensation from entering the MiniRAE. This external filter is in addition to the standard internal hydrophobic filter and is recommended for sampling in wet sample pits or anytime an 11.7 eV lamp is used. Even with this water trap in place, response time is only 5 seconds.

- **Elimination Vs Compensation for Moisture:** RAE does not eliminate the effect of moisture in PIDs, but compared to other PIDs the affects of moisture are drastically diminished. This method of eliminating moisture rather than compensating for moisture has less inherent disadvantages. Compensation for moisture, like using an electronic moisture compensating circuit, only turns up the amplifier circuit. This can lead to false alarms and presents an additional part of the monitor that requires calibration.
- **Less Lamp Cleaning:** RAE's laminar flow PID sensors direct the sample flow across the lamp lens rather than directing the sample flow

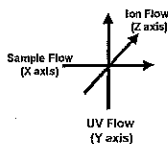
towards the lamp lens like many other PIDs. This results in less dirt and solvent vapors accumulating on the lamp lens because contaminants ideally "keep going" past the lamp face.

Advantages of the RAE Systems "3-D" Sensor

Sensor

The "3-D" sensor builds on the success of the "2-D" sensor. It has all the advantages of the "2-D" sensor with additional features. In the RAE Systems three-dimensional or "3-D" sensor, the sample is drawn across the lamp in a laminar manner forming the first of three dimensions. The light comes from the UV lamp at a 90-degree angle to the sample flow. The ion bias and sensing electrodes are not plates like in the 2-D sensor. Rather they are fingers placed in the sample flow so that the ion flow is across the sample in the Z-axis. This sensor is used in the MiniRAE 2000, UltraRAE and a variant of it is used in the ppbRAE.

- **Lowest Humidity Response:** the 3-D sensor eliminates the walls of the sensor in the 2-D version. Dirt can accumulate on sensor walls providing nuclei of condensation. Moisture is attracted to these nuclei first. If enough dirt is present, the moisture can condense and form an electrical path from the bias to the sensing electrode. This is called sensor "leakage" and users will obtain abnormally high readings. By eliminating the wall in the 3-D sensor, this source of moisture response is eliminated.
- **Better Linearity:** the 3-D sensor increases linearity from 0-2000 ppm in the 2-D sensor to 10,000 ppm.
- **Fastest response & recovery:** Less than 3 sec. to 90% up to 10,000 ppm!
- **Simple lamp & sensor cleaning:** The 3-D sensor is easily removed from the PID without tools. This allows operators, not instrument technicians, to quickly and easily clean grossly contaminated sensors. Under normal usage, the 3-D sensor will clean itself while on charge (ref. TN-165).



Tips on using a PID

Never Use Tygon Sample Tubing

Because tygon sample tubing quickly absorbs many chemical vapors, it should NEVER be used in with PIDs. Tygon tubing will reduce the PID reading when measuring many chemicals and may cause "false positives" when chemicals do not exist due to the "outgassing" of old chemicals from the tygon tubing. Tygon tubing is typically found as the remote sampling tubing supplied with most confined space monitors. Only Teflon, Teflon lined tygon or similar non-reactive tubing should be used with PIDs. Teflon tubing will not absorb chemicals but it can get coated. Clean contaminated Teflon tubing with anhydrous methanol (lamp cleaning solution) if it gets coated with chemical.

When to Clean a PID

From time to time a PID lamp and sensor requires cleaning. Historically, some PID users cleaned their lamps daily, often neglecting the sensor and sample components before the sensor. Typically frequent cleaning is not necessary and can lead to inadvertent damage to the PID lamp and sensor.

The following is a guideline on when a PID requires cleaning:

- **Clean PID Lamp & Sensor**
 1. When display creeps upwards after good zero
 2. When PID responds to moisture
 3. When movement of PID results in response on display
- **How to Clean**
 1. Use anhydrous methanol (Lamp cleaning solution)
 2. Clean sample probe and replace or clean filters. If PID holds a stable zero after this step then further cleaning may not be necessary
 3. Clean lamp face with lens tissue
 4. Clean sensor by immersion in cleaning solution (an ultrasonic cleaner will speed cleaning)
- **Drying the PID**
 1. Let air dry overnight
 2. Warm air (not hot) will speed drying

About the Author

A graduate of Cornell University, Christopher Wrenn is the Director of Portable Instrument & Monitor Business for RAE Systems and having been Product Applications Manager, Government Sales Manager and Eastern Regional Manager for RAE Systems previously. Just prior to RAE Systems, Mr. Wrenn was Northeastern Regional Manager for CairnsAir, a division of Cairns & Brothers. Previously, as Product Manager for Biomarine (Manufacturer of BioPak SCBA's), Mr. Wrenn was responsible for training military personnel responsible for the clean-up of chemical weapons on the use of long duration closed-circuit SCBA's (rebreathers). Mr. Wrenn's past experience in gas monitoring came as Director of Marketing for Neutronics, Inc., a

manufacturer of fixed gas monitoring for the chemical processing industry

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- RAE Systems: *Correction Factors and Ionization Potentials* (Technical Note TN-106)
- RAE Systems: *Setting Alarm Limits for Mixtures* (Technical Note TN-130)
- RAE Systems: *Measuring Correction Factors for Volatile Compounds with PIDs* (TN-120)
- PID Training Outline

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Attachment 1: Chain-of-Custody Example
Attachment 2: Field Custody Seal

NOTE: SITE-SPECIFIC CONDITIONS MAY WARRANT CHANGES IN PROCEDURES AND APPLICATIONS. FIELD STAFF SHALL DOCUMENT ACTUAL PROCEDURES IN THE APPROPRIATE FIELD LOGBOOK.

1.0 PURPOSE

The purpose of this SOP is to provide information on chain-of-custody (COC) procedures to be used to document sample handling and transport to a subcontract laboratory.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of COC recording process. A COC document (Attachment 1) is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during environmental projects. Use of a COC creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion.

3.0 DEFINITIONS

COC - A COC is a printed form (Attachment 1) that represents a written legal document accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

IATA - International Air Transport Association

ID - Identification

PDA - Personal Digital Assistant

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and times that it was collected.

Sample Collector - in the case of an environmental sample, this would be the emergency personnel (e.g., Hazmat) collecting the sample; for clinical samples sent from sentinel labs,

Sample Courier - The sample courier is the person, generally a commercial company (e.g., Federal Express) that is responsible for transporting the sample from the sample collector to the next sample handler.

Sample Custodian - The sample custodian receives the sample from the sample courier and has demonstrated competency in handling of samples and maintaining a COC.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures that deviate from those presented herein. The Project Manager is responsible for ensuring that COC procedures are implemented. The Project Manager also is responsible for determining that the analytical laboratory has met custody procedures.

Field Team Leader - The Field Team Leader is responsible for determining that COC procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate COC procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

5.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following are interferences or potential problems associated with sample handling:

- Samples should be protected from sunlight which may initiate photo-degradation of sample components. Coolers should be kept closed as much as possible.
- Delaying sample preservation (e.g., cooling with wet ice) may cause chemical reactions to occur, altering original sample composition. Improper sample preservation may adversely affect analytical results.

- Poor penmanship may cause the sample IDs to be inaccurately recorded by the subcontract laboratory. Write all information clearly on the COC. Minimize the number of strike-out lines if possible.
- Samples may be delayed during shipment if shipping papers are not completed appropriately. Identify all information needed for shipping documents before the field event to ensure that addresses, contact names, and billing numbers are known and available.
- Samples can also become contaminated from spills and nuclear coolers; therefore, all sample shipping equipment must be kept clean.

6.0 EQUIPMENT AND SUPPLIES

- COC Forms
- Sample Labels
- Custody Seals
- Tape
- Pen, indelible marker
- Commercial courier shipping forms
- URS shipping/billing number (for courier forms)
- Telephone numbers
- Shipping, packing supplies

7.0 PROCEDURES

The term "chain-of-custody" refers to procedures that ensure that evidence presented in a court of law is valid. The COC procedures track the evidence from the time and place it is first obtained to the final use, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

COC procedures, record keeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Custody procedures differ among laboratories. Custody procedures of the analyzing laboratory are identified prior to field activities. Field personnel must make arrangements with the appropriate laboratory for proper sample containers, preservatives, holding times, and sampling request forms. Sample custody must be traceable from the time of sample collection until results are reported. Sample custody procedures provide a mechanism for documenting information related to sample collection and handling. A COC form must be completed after sample collection and prior to sample

shipment or release. The COC form, sample labels, and field documentation must be crossed checked to verify sample identification, type of analyses, number of containers, sample volume, preservatives and type of containers. Additional information on sample handling and custody procedures can be found in EPA guidance documents.

7.1 Sample Identification/Sample Labels

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in electronic devices (e.g., Personal Digital Assistants [PDAs]), bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook or other field data records, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s)
- Project and Task Number
- Project Sample Number
- Sample location or sampling station number
- Date and time of sample collection and/or measurement
- Field observations
- Equipment used to collect samples and measurements
- Calibration data for equipment used

Measurements and observations shall be recorded using indelible ink.

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the project document (sampling plan). Each sample container is identified by a sample label. Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project Name
- Sample Identification - the unique sample number identifying this sample
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 12/21/10)

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.)
- Medium - Water, soil, sediment, sludge, waste, etc, if required.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - volatiles, semi-volatiles, pesticides, metals, cyanide, etc.
- Sampled By - *printed initials* of the sampler.

Generally, the subcontract laboratory will provide pre-printed labels for projects if requested. The laboratory should leave the fields for date, time, and sampled by empty. These fields will be completed by sampling personnel at the time of sample collection.

The sample identification (ID) consists of the following parts (USS, 2008):

SWMA-Boring Location-Boring Depth-Date-Field QC (as needed)

SWMA - The first identifier of the sample name are two letters designating the Solid Waste Management Area (SWMA). Samples from the East End will be identified as "EE." Samples from East Lake will be identified as "EL," etc.

Boring Location - The second identifier of the sample name is a five-part sample source code. Examples include "SB" (Soil Boring) followed by the location number. Samples from soil boring 10 will be identified as "SB010."

Boring Depth - The third identifier of the sample name is a two character and three-digit sample depth code. Examples include surface soil (SS), subsurface soil (SB), surface water (SW), sediment (SD), etc. Samples from surface water location 8 will be identified as "SW008." (Note: Samples of surface soil do not require the three digit depth code. See examples below.)

Date - The fourth identifier of the sample name is an eight-digit number representing the sample collection date. For example, a sample collected on July 2, 2009 would have the code 07022009.

Field QC - The fifth identifier of the sample name is an optional code used only when QC samples are submitted to the laboratory. Examples include trip blank (TB), field duplicate (FD), matrix spike (MS), matrix spike duplicate (MSD), equipment blank (EB), and source water blank (SC). For TB and EB QC samples, the two letter code will be followed by a sequential number (e.g., TB05).

Below are some examples of possible sample IDs:

- EL-SB004-SB002-10192009 - The 2nd subsurface sample collected from sample location 4 at the Coke Plant SWMA on October 19, 2009
- EL-SW004-SW001-10312009 - A surface water sample collected from sample location No. 4 at the first depth at the East Lake SWMA on October 31, 2009
- CP-MW011-SB01-12122009 - The first subsurface soil sample collected during installation of Monitoring Well No. 11 at the Coke Plant SWMA on December 12, 2009
- EL-SB022-SS-10312010 - A surface soil sample collected from sample location No. 22 at the East Lake SWMA on October 31, 2010.
- EL-SB004-PZ-10312009 - A groundwater sample collected from a piezometer at sample location No. 4 at the East Lake SWMA on October 31, 2009
- CP-04252009-TB05 - The 5th trip blank sample associated with samples collected at the Coke Plant SWMA on April 25, 2009
- WE-09252010-EB22 - The 22nd equipment blank sample associated with samples collected at the West End SWMA on September 25, 2010
- CP-SB08-SS-10022009-FD - A field duplicate sample of a surface sample collected from sample location 8 at the Coke Plant SWMA on October 2, 2009
- CP-SB08-SS-10022009-MS/MSD - The QC sample for MS/MSD analysis of a surface sample collected from the sample location 8 at the Coke Plant SWMA on October 2, 2009.

7.2 Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

7.2.1 Field Custody Procedures

Samples must be collected as described in the site sampling plan. Care must be taken to record precisely the sample identification and to ensure that the sample ID on the label matches the COC exactly.

The sampling team undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched. When photographs are taken of the sampling as part of the documentation procedure, they will be entered into a Photo Document Log with description of the photo; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.

Sample labels shall be completed for each sample as described in Section 7.1, using indelible ink unless prohibited by weather conditions.

Samples may require short term storage in field locations prior to delivery to the laboratory for analyses. The storage may be in vehicles or lodging locations. The samples must be secured to limit access to them. A locked vehicle is considered controlled access. However, simply a locked lodging room is not secure due to potential custodial access. If an unattended lodging room is used for sample storage, the samples must be further secured using a custody seal (Attachment 2).

7.2.2 Transfer of Custody and Shipment

A COC must be completed and accompany all samples for subcontract laboratory analysis. When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date, and note the time on the COC. This COC documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The COC is filled out as given below.

- Enter header information (project number, samplers, project manager, office address and phone number, and project name if not completed by the subcontract laboratory).
- Enter sample specific information (sample number, media, sample analysis required and analytical method, grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express). If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner, only if using shipping papers in hard copy.
- Place the original (top, signed copy) of the COC in a plastic zipper-type bag or other appropriate sample shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing (Attachment 2). The custody seal is an integral part of the COC process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory. Place the seal across the shipping container opening so that it would be broken if the container was to be opened.
- Complete other carrier-required shipping papers.

Other important information related to COC documentation includes:

- The custody record is completed using indelible ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

- Regulations must be observed regarding the shipment of any "Dangerous Goods." Sample containers and certain field equipment may be defined as "Dangerous Goods" such that special requirements must be followed for their shipment. Air shipment of "Dangerous Goods" is regulated by the International Air Transport Association (IATA) as described in "Dangerous Goods Regulations." Shipment by ground is regulated by the U.S. Department of Transportation (DOT). Furthermore, individual shippers (e.g., Federal Express) may have additional requirements for "Dangerous Goods" shipment. The shipment of "Dangerous Goods" must be consistent with the instruction and authorization of the analytical laboratory shipping and receiving coordinator and its Health and Safety director.

Note: If you are unfamiliar with proper shipping requirements for your samples, it is your responsibility to seek review and understand URS Safety Management Standard (SMS) 048 or seek advice from the project manager, or your office H&S office. Additionally, you may call the URS shipping hotline for hazardous materials/dangerous goods to provide answers to specific shipping questions. The number is 800-381-0664.

8.0 QUALITY ASSURANCE

Sampling personnel should periodically check completion of the COC by other field personnel, prior to entering the COC in the cooler. The check would verify the field IDs against the IDs on the COC. Subsequently, once received at the laboratory, the laboratory should provide receipt acknowledgment form so field personnel can verify accurate log-in by the subcontract laboratory. Where differences are found, the field personnel should notify the laboratory of the error, and the laboratory should document the change in the log-in narrative or the case narrative summary of the laboratory report.

Not applicable.

10.0 REFERENCES

- USEPA, 2002. United States Environmental Protection Agency. Guidance for Quality Assurance Project Plans. EPA QA/R-5. EPA/240/R-02/009. USEPA Office of Environmental Information, Washington, D.C. December 2002.

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ATTACHMENT 2: FIELD CUSTODY SEAL

TestAmerica

**FIELD EQUIPMENT OPERATION AND
MAINTENANCE PROCEDURES -
FIELD LOGBOOK**

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SOP Number: F303
Effective Date: October 2009

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1.0 PURPOSE

This SOP describes the process for maintaining a Field Logbook.

2.0 SCOPE

The Field Logbook is a document which records all major on-site activities conducted during a field investigation. At a minimum, the following activities/events shall be recorded in the Field Logbook by each member of the field crew.

- Arrival/departure of site workers and visitors
- Arrival/departure of equipment
- Sample pickup (sample numbers, carrier, time)
- Sampling activities
- Start or completion of boreholes, monitoring wells, or sampling activities
- Health and safety issues

The Field Logbook is initiated upon arrival at the site for the start of the first on-site activity. Entries are made every day that on-site activities take place. At least one field logbook shall be maintained per site.

The Field Logbook becomes part of the permanent site file. Because information contained in the Field Logbook may be admitted as evidence in legal proceedings, it is critical that this document is properly maintained.

3.0 DEFINITIONS

Field Logbook - The Field Logbook is a bound notebook with consecutively numbered pages. Upon entry of data, the logbook requires the signature of the responsible data/information recorder.

4.0 RESPONSIBILITIES

The Field Team Leader is responsible for maintaining a master field logbook for the duration of on-site activities. Each member of the sampling crew is responsible for maintaining a complete and accurate record of site activities for the duration of the crew members participation in the project.

5.0 PROCEDURES

The following sections present some of the information that must be recorded in the Field Logbook. In general, a record of all events and activities, as well as other potentially important information shall be recorded by each member of the field team.

5.1 Cover

The inside cover or title page of each field logbook shall contain the following information:

- Project Number
- Project name and location
- Name of Field Team Leader
- Baker's address and telephone number
- Start date
- If several logbooks are required, a sequential Field Logbook number

It is good practice to list important phone numbers and points of contact here.

5.2 Daily Entries

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded by each team member.

- Date
- Start time
- Weather
- All field personnel present
- All visitors present
- Other pertinent information (i.e., planned activities, schedule changes, expected visitors, and equipment changes)

During the day, an ongoing record of all site activities should be written in the logbook. The master logbook kept by the field team leader need not duplicate that recorded in other Field Logbooks, but should summarize the information in other books and, where appropriate, reference the page numbers of other logbooks where detailed information pertaining to a subject may be found.

Some specific information which must be recorded in the logbook includes the following:

- Equipment used, equipment numbers, calibration, field servicing
- Field measurements
- Sample numbers, media, bottle size, preservatives, collection methods, and time
- Test boring and monitoring well construction information, including boring/well number and location
- Sketches for each sample location including appropriate measurements if required
- Photograph log
- Drum log
- Other pertinent information

All entries should be made in indelible ink; all pages numbered consecutively, and all pages must be signed or initialed and dated by the responsible field personnel completing the log. No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single line, initialed, and dated.

5.3 Photographs

If photographs are permitted at the site, the record shall be maintained in the Field Logbook. When movies, slides or photographs are taken of any site location, they are numbered or cross-referenced to correspond to logbook entries. The name of the photographer, date, time, site location, site description, direction of view and weather conditions are entered in the logbook as the photographs are taken. Special lenses, film, or other image- enhancement techniques also must be noted in the Field Logbook. Once processed, photographs shall be serially numbered and labeled corresponding to the Field Logbook entries.

6.0 QUALITY ASSURANCE RECORDS

Once on-site activities have been completed, the Field Logbook shall be considered a quality assurance record.

7.0 REFERENCES

None.

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Table 1: Sample Container, Storage and Preservation Guidelines

NOTE: SITE-SPECIFIC CONDITIONS MAY WARRANT CHANGES IN PROCEDURES AND APPLICATIONS. FIELD STAFF SHALL DOCUMENT ACTUAL PROCEDURES IN THE APPROPRIATE FIELD LOGBOOK.

1.0 PURPOSE

The SOP describes the type and quantity of quality control (QC) samples to be collected for most field sampling operations. The goal of including QC samples with any sampling or analytical event is to be able to identify, measure, and control the sources of error that may be introduced from the time of sample-container preparation through sample analysis. Quality assurance (QA) samples are used as an assessment tool to determine if environmental data meet the quality criteria established for a specific application. QC samples are generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system. Several types of samples may be used for establishing QA/QC. Any one sample may serve to establish QA, QC, or both.

2.0 SCOPE

QC samples are those samples (usually collected in the field) that are sent to the laboratory along with the environmental samples in order to evaluate site conditions and laboratory precision and accuracy. Evaluation of the results from the QC samples allows for the quality of the data to be assessed. There are five different types of QC samples: trip blanks, equipment rinse blanks, field blanks, duplicates and matrix spike/matrix spike duplicate (MS/MSD) samples. The first three types of QC samples are used to assess field conditions during sampling and/or transport of the environmental samples. The latter two types of QC samples are used by the laboratory to help assess precision and accuracy. (The laboratory also has other internal samples and procedures to assess precision and accuracy.)

3.0 DEFINITIONS

Accuracy - Accuracy is defined as the closeness or agreement between an observed value and an accepted reference value.

Bias - Bias is defined as the deviation of a measured value from a reference value or a known spiked amount, and is determined by calculating percent recovery.

Duplicates - Duplicates are collected to help assess laboratory reproducibility (precision). Solid matrix samples are homogenized before being split, except for VOAs, which are not homogenized because of potential volatile loss. Liquid matrix samples are collected simultaneously. The same analyses are completed on the duplicate as on the environmental sample.

Equipment Rinse Blanks - Equipment rinse blanks are samples of ASTM Type II water (provided by the laboratory) or distilled water passed over decontaminated sampling equipment. They are used as a measure of the effectiveness of the decontamination procedure. The equipment rinse blank is analyzed for the same parameters as the environmental samples collected from the piece of equipment.

Field Blanks - Field blanks are samples of source water used for decontamination and steam cleaning. At a minimum there is one sample collected for each source of water used per sampling event. The field blank is analyzed for all the parameters tested during the sampling event.

Performance Evaluation Sample - PE samples are prepared by an independent manufacturer that are submitted blind to a laboratory to assess the accuracy and precision of their measurements.

Precision - Precision is a measure of the closeness of agreement among individual measurements. Precision is determined by calculating the relative standard deviation or the coefficient of variation for at least eight (8) matrix-spike samples.

MS/MSD - MS/MSD samples are used by the laboratory (but collected in the field) to help determine both precision and accuracy of analysis. Additional volume of sample is required when requesting that a laboratory perform MS/MSD analyses.

Trip Blank - Trip blanks are 40-ml volatile organic analysis (VOA) vials of ASTM Type II water that are filled at the laboratory, transported to the sampling site, and returned to the laboratory with environmental VOA water samples. Trip blanks are not opened in the field.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

5.0 INTERFERENCE AND POTENTIAL PROBLEMS

QA/QC samples are collected and analyzed in addition to environmental samples to assist in identifying the origin of both field and laboratory contamination. In order to provide useful information, QA/QC samples must be taken, prepared and analyzed in the same manner as the environmental samples. Failure to do so may result in invalid QA/QC interpretations.

6.0 EQUIPMENT AND SUPPLIES

The site specific equipment/apparatus required to collect QA/QC samples is the same as the equipment/apparatus required to collect the environmental samples. Refer to the relevant SOPs for sampling techniques to obtain lists of the equipment/apparatus required for sampling. The amount of sample to be collected, the proper sample container, chemical preservation and storage requirements are shown in Table 1 (Sample Storage and Preservation).

7.0 PROCEDURES

The procedures for QC sample collection and the frequency at which each type of sample should be collected is described below.

7.1 Trip Blanks

Trip blanks (one pair of 40 ml vials or one 40 ml vial) are sent to the laboratory in each cooler which contains water samples for volatile organic analyses. The trip blanks are prepared by the laboratory and shipped to the site with the sample containers. The trip blank should also be kept in the field, with the volatile samples, during the period of sample collection. If multiple trip blanks are used throughout a sampling event they should be kept in a separate cool away from other sample containers until they are used. New trip blanks need to be requested for each sampling event from the laboratory. Trip blanks from previous sampling event need to be properly disposed. Analyses of the trip blank will determine if the sample containers were contaminated prior to sampling or during transport.

7.2 Equipment Rinse Blanks

Equipment rinsate blanks are collected by pouring chemical-free water (provided by the laboratory) or distilled water over decontaminated sampling equipment and collecting the rinsate. These are collected usually at a frequency of once per week per sampling crew and are analyzed for the same parameters as are the samples collected from that equipment. If two (or more) different types of equipment are used to collect samples in the same day (say by two field teams, one collecting soil samples from split spoons and one collecting samples from direct-push drilling), then two separate equipment rinsate blank samples may be collected. It is also possible that multiple crews are using the same type of equipment but each crew has their own piece of equipment (i.e., two crews using

two submersible stainless steel pumps), therefore each crew would need to collect an equipment rinse blank at a frequency typically specified in the project site's SAP and QAPP. The equipment rinse blank results may be used to qualify data that is impacted by improper cleaning of equipment.

7.3 Field Blanks

One field blank per source of water used for decontamination per sampling event is collected for all the parameters analyzed during that sampling event. In general, two field blanks are collected - one from the potable water source used for steam cleaning and one from distilled water used for equipment decontamination (i.e., purchased at a local store or provided by the laboratory). The field blank is collected by opening up the water source at the sampling locations and pouring the water directly into the appropriate sample bottles. Analysis of the sample will indicate whether contamination was introduced into the samples during the collection process. A new field blank shall be collected if the water source changes, or at minimum once per quarter.

7.4 Field Duplicates – Aqueous and Solids

Field duplicates are field samples obtained from one location. Solids are homogenized with thorough hand mixing and divided into separate containers. They are treated as separate samples throughout the remaining sample handling and analytical processes. Aqueous samples are collected in various manners but usually the VOA sample is collected first along with the field duplicate VOA sample, then the Semi-Volatiles are collected along with the field duplicate Semi-Volatile samples (if applicable), then the metals sample is collected along with the field duplicate metals sample (if applicable), then any remaining samples are collected along with the field duplicate being analyzed for the sample parameter. This process is continued until all samples are collected.

Field duplicate samples are used to assess total error (precision) associated with sample heterogeneity, sample methodology, and analytical procedures. This procedure is useful in determining total (sampling and analytical) error because it evaluates sample collection, sample preparation, and analytical procedures. Field replicates may be especially important when determining precision for critical samples with contamination concentrations near or above the action level (action level refers to the minimum concentration necessary to require some type of remediation, monitoring, or enforcement). A minimum of eight replicate samples are required in order for valid statistical analysis to be performed. Field replicates may be collected on a site specific basis and do not have to be collected at all sites investigated.

Field duplicates are typically collected at a frequency of 10 percent (one duplicate or per 10 samples), or at a minimum one per day per crew. Field duplicates are primarily used to check the precision and consistency of the sampling procedures used and as a check of laboratory accuracy.

7.5 Matrix Spike/Matrix Spike Duplicates – Aqueous and Solids

MS/MSDs are environmental samples that are spiked in the laboratory or in the field with a known concentration of a target analyte(s) to verify percent recoveries. MS/MSD samples are primarily used to check sample matrix interferences. They can also be used to monitor laboratory performance. However, a data set of at least three or more results is necessary to statistically distinguish between laboratory performance and matrix interference. The minimum frequency of MS/MSDs should be 5 percent of the total number of samples being analyzed for the target chemicals. MS/MSD samples are also used to evaluate error due to laboratory bias and precision. One MS/MSD pair per target analyte should be analyzed and the average percent recovery should be calculated to assess bias.

MS/MSD samples are collected in the same manner as for a duplicate sample, except that additional volume is required for analysis. The frequency of collection is one MS/MSD pair (or two additional sample volumes) for each 10 environmental samples collected of similar matrix or per each project site's SAP and QAPP (e.g. groundwater, surface water, soil).

7.6 Performance Evaluation Samples

Performance-evaluation (PE) samples evaluate the overall bias of the analytical laboratory and detect any error in the analytical method used. These samples are usually prepared by a third party (e.g., Environmental Resources, Inc., Arvada, Colorado), which is known to the preparer but unknown to the contract laboratory. The chemical used to prepare the PE sample is the same as the chemicals of concern. Laboratory procedural error is evaluated by the percentage of chemical identified (percent recovery) in the PE sample. When analyzed, the minimum frequency of PE samples is one per chemical of interest. The use of PE samples will be determined on a case-by-case basis.

7.7 Background Samples

Background samples are collected from area(s), either onsite or offsite where there is little or no chance of contamination. Background samples are collected in an attempt to determine the natural composition of the soil (especially important in areas with high concentrations of naturally occurring metals) and are considered "clean" samples. They provide a basis for comparison of contaminant concentration levels with samples collected onsite. At least one background soil sample should be collected. More are warranted when site specific factors such as natural variability of local soil, multiple onsite contaminant source areas, or off-site facilities potentially contributing to soil contamination exist. Background samples may be collected in order to evaluate potential error associated with sampling design, sampling methodology, and analytical procedures. Background samples may be used to determine bias and precision if at least eight replicates are spiked with the chemical of interest at a concentration equal to the action level, and then analyzed.

7.8 Sample Collection Records – Aqueous and Solids

Records of collection of QC samples are kept in the field logbooks and on the Chain-of-Custody forms. Evaluation of the results from the QC samples is performed by the laboratory and through data validation for the MS/MSD samples. Results of the other QC samples are compared to analytical results from the sampling event to determine if any field procedures, or sample transportation and handling may have adversely affected the concentrations found in the environmental samples.

8.0 QUALITY ASSURANCE RECORDS

Equipment blanks will be collected from water source for steam-cleaning equipment as quality assurance records. The frequency of collection of equipment blanks from either drilling tools or field sampling equipment shall be specified in the SAP and QAPP for a given project. Documentation in the drillers' logbook shall serve as a QA record of decontamination. The drillers will oversee decontamination procedures to ensure that they have been completed according to the procedures outlined above.

9.0 HEALTH AND SAFETY

All site-specific safety procedures should be followed when collecting samples. Chemical preservatives should be noted on Daily Job Safety Analysis sheets as well.

Sampling personnel should be aware of chemical preservatives that are present in sample containers for aqueous analyses.

10.0 REFERENCES

USEPA, 1986. Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986.

Hazardous Waste Remedial Actions Program, 1990. Requirements for Quality Control of Analytical Data. DOE/HWP-63R1, US Department of Energy, Oak Ridge, Tennessee.

TABLE 1: Sample Container, Storage, and Preservation Guidelines

Analytical Parameter	Matrix ⁽¹⁾	Container	Preservation	Holding Time ⁽²⁾
VOCs (8260B)	Aqueous	3-40 mL glass vials with Teflon®-lined septum caps	Cool, ≤6°C 1:1 HCl to pH ≤ 2*	14 days with pH≤2
	Solid ⁽⁴⁾	Lab preserved - 3 EnCore™ samples ⁽³⁾ or Terracore™ Syringe with 3, 40-mL pre-weighed glass jar with Teflon®-lined septum and stir bars or 1-L oz glass jar with Teflon®-lined septum ⁽⁵⁾	Soil/Sediment/Waste - Cold preservation: 5 grams of sample to be frozen in 3 mL of water within 48 hours of collection	14 days. Maximum holding time for preservation of EnCore Sampler is 48 hours.
SVOCs (8270C) ⁽⁶⁾	Aqueous	2-1 liter amber glass with Teflon®-lined lid for each parameter.	Cool, ≤6°C	Extraction: 7 days; Analysis, within 40 days of the start of extraction
	Solid	1-16 oz. wide mouth glass with Teflon®-lined lid for all parameters or 4 oz. glass wide mouth with Teflon®-lined lid for one parameter	Cool, ≤6°C	Extraction: 14 days; Analysis, within 40 days of the start of extraction
PAHs by GC and HPLC (8310) ⁽⁷⁾	Aqueous	2-1 liter amber glass with Teflon®-lined lid for each parameter.	Cool, ≤6°C	Extraction: 7 days; Analysis, 40 days of the start of the extraction
	Solid	1-16 oz. wide mouth glass with Teflon®-lined lid for all parameters or 4 oz. glass wide mouth with Teflon®-lined lid for one parameter	Cool, ≤6°C	Extraction: 14 days; Analysis, 40 days of the start of the extraction
Organophosphorus Pesticides (8311A) ⁽⁸⁾	Aqueous	2-1 liter amber glass with Teflon®-lined lid for each parameter.	Cool, ≤6°C	Extraction: 7 days; Analysis, 40 days of the start of the extraction
	Solid	1-16 oz. wide mouth glass with Teflon®-lined lid for all parameters or 4 oz. glass wide mouth with Teflon®-lined lid for one parameter	Cool, ≤6°C	Extraction: 14 days; Analysis, 40 days of the start of the extraction
Herbicides (8315A) ⁽⁹⁾	Aqueous	2-1 liter amber glass with Teflon®-lined lid for each parameter.	Cool, ≤6°C	Extraction: 7 days; Analysis, 40 days of the start of the extraction

Analytical Parameter	Matrix ⁽¹⁾	Container	Preservation	Holding Time ⁽²⁾
	Solid	1-16 oz. wide mouth glass with Teflon®-lined lid for all parameters or 4 oz. glass wide mouth with Teflon®-lined lid for one parameter	Cool, ≤6°C	Extraction, 14 days; Analysis, 40 days of the start of the extraction
Organochlorine Pesticides (8081A) ⁽³⁾	Aqueous	2-1 liter amber glass with Teflon®-lined lid	Cool, ≤6°C	Extraction, 7 days; Analysis, 40 days of the start of the extraction
	Solid	4 oz. glass wide mouth with Teflon®-lined lid	Cool, ≤6°C	Extraction, 14 days; Analysis, 40 days of the start of the extraction
PCBs (8082) ⁽⁴⁾	Aqueous	2-1 liter amber glass with Teflon®-lined lid	Cool, ≤6°C	Extraction, 7 days; Analysis, 40 days of the start of the extraction
	Solid	4 oz. glass wide mouth with Teflon®-lined lid	Cool, ≤6°C	Extraction, 14 days; Analysis, 40 days of the start of the extraction
Dioxins / Furans (LRMS) (8280A) (screening method)	Aqueous	2-1 liter amber glass with Teflon®-lined lid	Cool, ≤6°C; Store in dark; if sample pH >9, adjust to pH 7-9 with H ₂ SO ₄	Extract within 30 days; Analyze within 45 days of extraction
	Solid	4 oz. glass wide mouth with Teflon®-lined lid	Cool, ≤6°C	Extract within 30 days; Analyze within 45 days of extraction
Metals (6010B, 7000A series) Mercury (CVAA) (7470A - Aqueous) (7471A - solid / waste)	Aqueous	1 liter glass or polyethylene container	HNO ₃ to pH ≤ 2	6 months (metals); 28 days (mercury)
	Solid	4 oz. glass wide mouth with Teflon®-lined lid	Cool, ≤6°C	6 months (metals); 28 days (mercury)

Analytical Parameter	Matrix ⁽¹⁾	Container	Preservation	Holding Time ⁽²⁾
Cyanide (9012A) / Amenable / Total	Aqueous	250 mL plastic	NaOH to pH >12; If residual chlorine present, 0.6g ascorbic acid; Cool, ≤6°C	14 days
	Solid	Solid aliquot will be taken from metals container	Not Specified / Cool, ≤6°C	Not Specified / 14 days
Petroleum Hydrocarbons HEM/SGT (1664)	Aqueous	1 liter glass	Cool, ≤6°C; HCl or H ₂ SO ₄ to pH <2	28 days
	Solid	4 oz. glass wide mouth with Teflon®-lined lid	Cool, ≤6°C	28 days
Acidity (305.1) / Alkalinity (310.1) / 2320B	Aqueous	250 mL plastic or glass	Cool, ≤6°C	14 days
	Solid	NA	NA	NA
Ammonia (350.3)	Aqueous	1 Liter plastic container	Cool, ≤6°C; H ₂ SO ₄ to pH < 2	28 days
	Solid	NA	NA	NA
Ash (D1553-83)	Aqueous	** Ash, Percent Moisture, TS, TSS, Turbidity, VSS, and Volatile Solids will be combined in 1 Liter plastic container	Cool, ≤6°C	7 days
	Solid	NA	NA	NA
BOD and Carbonaceous BOD (405.1)	Aqueous	1 Liter plastic container	Cool, ≤6°C	48 hours
	Solid	NA	NA	NA
COD (410.4)	Aqueous	1 Liter plastic container	Cool, ≤6°C; H ₂ SO ₄ to pH < 2	28 days
	Solid	NA	NA	NA
Chromium (Cr ⁶⁺) (7196A)	Aqueous	250 mL plastic container	Cool, ≤6°C	24 hours
	Solid	2 oz glass	NA	30 days to digestion, 96 hours after digestion
Conductivity (9050A)	Aqueous	1 Liter plastic container	NA	Field Analysis
	Solid	NA	NA	NA
Dissolved Oxygen (360.1)	Aqueous	300 mL glass stoppered BOD bottle	NA	Field Analysis
	Solid	NA	NA	NA

Analytical Parameter	Matrix ⁽¹⁾	Container	Preservation	Holding Time ⁽²⁾
Inorganic Anions by Ion Chromatography (300.0)	Aqueous	1 Liter plastic container	Cool, ≤6°C	48 hours - Nitrate, nitrite, orthophosphate; 28 days - Chloride, fluoride, sulfate
	Solid	NA	NA	NA
Nitrate-Nitrite (353.2)	Aqueous	1 Liter plastic container	H ₂ SO ₄ to pH < 2	28 days
	Solid	NA	NA	NA
Percent Moisture (D2216-90)	Aqueous	NA	NA	NA
	Solid	4 oz. jar	Cool, ≤6°C	7 days
pH (9040B - Aqueous) (9040C - solid/waste)	Aqueous	1 Liter plastic container	NA	This test could be performed in the field; Analyze immediately.
	Solid	4 oz glass	Cool, ≤6°C	Analyze as soon as possible.
Total Recoverable Phenolics (9065)	Aqueous	1 liter glass recommended	Cool, ≤6°C; H ₂ SO ₄ to pH < 4	28 days
	Solid	NA	NA	NA
Phosphorus (Total) (365.2 / 365.3)	Aqueous	1 Liter plastic container	H ₂ SO ₄ to pH < 2	28 days
	Solid	NA	NA	NA
Sulfide (9030B)	Aqueous	300 mL plastic, no headspace	Cool, ≤6°C; Add 4 drops of 2N zinc acetate per 100 mL of sample, adjust the pH to >9 with 6N NaOH solution	7 days
	Solid	Cool	≤6°C	Analyze as soon as possible
Sulfite (SO ₃) (377.1)	Aqueous	150 mL plastic	No preservative required	Analyze immediately. This test should be performed in the field.
	Solid	NA	NA	NA
TDS (Filterable) (160.1)	Aqueous	250 mL plastic or glass	Cool, ≤6°C	7 days
	Solid	NA	NA	NA
TKN (351.3)	Aqueous	1 Liter plastic container	Cool, ≤6°C; H ₂ SO ₄ to pH < 2	28 days
	Solid	NA	NA	NA

Analytical Parameter	Matrix ⁽¹⁾	Container	Preservation	Holding Time ⁽²⁾
TOC (9060-Aqueous/Walkley-Black-Solids)	Aqueous	2-40mL VOA vials	Cool, ≤6°C; H ₂ SO ₄ or HCl to pH < 2	28 days
	Solid	4 oz glass	Cool, ≤6°C	28 days
TOX (9020B)	Aqueous	250 mL glass, Teflon®-lined lid, no headspace	Cool, ≤6°C; H ₂ SO ₄ to pH < 2	28 days
	Solid	NA	NA	NA
Total Solids (160.3) TSS and VSS (160.2)	Aqueous	1 Liter plastic container	Cool, ≤6°C	7 days
	Solid	NA	NA	NA
Turbidity (180.1)	Aqueous	1 Liter plastic container	Cool, ≤6°C	48 hours
	Solid	NA	NA	NA
Volatile Solids (160.4)	Aqueous	1 Liter plastic container	Cool, ≤6°C	7 days
	Solid	NA	NA	NA

Notes:

⁽¹⁾ Solid matrix type includes soil, sediment, sludge or other solids not classified as waste.⁽²⁾ Holding times are calculated from the date of collection.⁽³⁾ Double volume will be collected for MS/MSD samples or field duplicates except for Appendix IX VOCs (7 EnCore™ samplers or 40-mL vials used with Terracore™ syringe will be collected for MS/MSD analyses).⁽⁴⁾ 1-2 oz. Plastic for % solids (Required if no other soil jars are being submitted)⁽⁵⁾ 1, 4-ounce glass jar with Teflon®-lined septum will be used for solid samples not collectible by EnCore™ sampling.⁽⁶⁾ Generally, parameters will be combined with other like parameters depending upon laboratory requirements.

*Some Appendix IX VOCs are lost with the use of acid preservation. The usability of results from analyses conducted on samples using acid preservation will be described in the data validation reports.

NA - Not Applicable

HEM/SGT - Hexane Extractable Method/Silica Gel Treatment

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NOTE: SITE-SPECIFIC CONDITIONS MAY WARRANT CHANGES IN PROCEDURES AND APPLICATIONS. FIELD STAFF SHALL DOCUMENT ACTUAL PROCEDURES IN THE APPROPRIATE FIELD LOGBOOK.

1.0 PURPOSE

The purpose of this SOP is to provide a general reference regarding the proper decontamination of drilling rigs, and field chemical sampling and analytical equipment. In addition, decontamination reduces health hazards and prevents the spread of contaminants off-site.

2.0 SCOPE

This procedure addresses drilling equipment, test pit equipment (i.e. backhoe) and monitoring well material decontamination and should be consulted during the preparation of project-specific plans. This procedure applies to all field sampling equipment including, but not limited to, soil samplers (split-spoons), bailers, beakers, trowels, filtering apparatus, and pumps. This procedure should be consulted when decontamination procedures are being developed as part of project-specific plans. Additionally, current USEPA regional procedures and decontamination guidance as well as state guidance should be reviewed. This procedure does not pertain to personnel decontamination (e.g., face masks).

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

De-ionized water - Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits). Organic-free water may be substituted for de-ionized water.

Drilling Equipment - All power equipment used to collect surface and sub-surface soil samples or install wells. Rotary drilling, sonic drilling, and direct push are included in this definition.

Organic-free water - Tap water that has been treated with activated carbon and de-ionizing units. At a minimum, the finished water must meet the analytical criteria of de-ionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels by the contract laboratory

for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

Quality Assurance Project Plan - (QAPP) A QAPP is a written document that outlines the procedures a monitoring project will use to ensure that samples, data, and subsequent reports are of high enough quality to meet project objectives. It provides a description of the policies, organization, practical activities, and quality control procedures necessary for achieving the study's objectives. Quality control procedures are goals, plans, and guidelines that are spelled out to insure a high level of quality in the collection and analysis of the data and the handling of samples.

Sampling and Analysis Plan - (SAP) A SAP typically consists of two components: a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). The SAP describes how the study is done, including sampling techniques and data analysis procedures; data interpretation techniques, including statistical analyses; quality assurance procedures and quality control techniques.

Soap: A standard brand of phosphate-free laboratory detergent, such as Luminol®.

Tap water: Water from any potable water supply. De-ionized water or organic-free water may be substituted for tap water.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Drilling Inspector (Site Geologist, Rig Geologist etc.) - It is the responsibility of the drilling inspector to ensure that the drilling subcontractor follows these, or other project-specific procedures as directed by the Field Team Leader.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

5.0 POTENTIAL PROBLEMS AND INTERERENCES

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte-free water. Distilled water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Contaminant-free

deionized water is available from commercial vendors or laboratories and may be shipped directly to the site.

6.0 EQUIPMENT AND SUPPLIES

The following are standard materials and equipment used as a part of the decontamination process:

- Large/heavy Equipment (i.e., Drill rigs, backhoes, augers, drill pipe, bits, casing, and screen)
- High-pressure pump with steam-spray unit
- Stiff-bristle brushes
- Small/sampling Equipment (i.e., Split spoons, spanulas, bailers, bowls, and pumps)
- Soap
- Polyethylene sheeting
- Stiff-bristle brushes
- Wash bottles or manual pump sprayer
- Solvents, e.g., 10% methanol solution (optional)
- Distilled/deionized water, contaminant-free
- Tap water (generally but non-potable may also be used)
- Appropriate protective clothing
- Air purifying respirator (APR)
- Field log book
- Non-phosphate detergent
- Selected high purity, contaminant-free solvents
- Long-handled brushes
- Trash containers
- Paper towels
- Galvanized tubs or equivalent (e.g., baby pools)
- Metal/plastic container for storage and disposal of contaminated wash solutions
- Pressurized sprayers
- Trash bags
- Aluminum foil
- Sample containers

7.0 PROCEDURES

The various drilling equipment and materials involved with test boring, test pit excavation, subsurface soil sampling, and monitoring well construction must be properly decontaminated to ensure that chemical analysis results reflect actual concentrations present at sampling locations. These procedures will minimize the potential for cross contamination between sampling locations and the transfer of contamination off site. Such equipment includes drilling rigs, backhoes, augers, downhole tools, well casings, and screens. Split-spoon soil samplers and other similar soil sampling devices shall be decontaminated. Cleaning procedures are listed in the following sections.

7.1 Decontamination Area/Pad - Large Equipment Cleaning

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.
- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

The drilling contractor will construct a decontamination area at a designated area onsite. Decontamination of drilling equipment will be performed over the decontamination pad. A shallow, above-surface tank may be used or a pumping system with discharge to a waste tank may be installed. In some cases, steam-cleaning/pressure washing water will be allowed to soak back into the ground.

Prior to entering or leaving the site, large equipment not directly utilized for sampling will be decontaminated by steam-cleaning in a designated area. The decontamination procedure consists of steam-cleaning the equipment, using potable water as the steam source, to remove visible signs of soils or wastes, and allowing the equipment to air dry. If necessary, the equipment may be cleaned with a scrub brush and soapy-water solution prior to steam cleaning to remove visible signs of contamination. Verify that the drilling contractor sprays areas (rear of rig or backhoe) exposed to contaminated soils using steam or high-pressure sprayer.

Drill rigs and tools will be cleaned between each location and prior to the initiation of any sampling. Document that decontamination was performed in the appropriate logbook.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning area on site to minimize potential impacts. Enclose steam-cleaning operations. For example, augers and drilling rods can be steam cleaned in drums.
- Tarpaulins also can be placed around the steam cleaning area to control emissions.

7.3 Small Field Equipment Decontamination Procedures

In order to ensure that chemical analysis results reflect actual concentrations present at sampling locations, sampling equipment must be properly decontaminated prior to the field effort during the sampling program (i.e., between sampling locations) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sampling locations and the transfer of contamination off site. Preferably, sampling equipment should be dedicated to a given sampling location. If this is not possible, equipment must be decontaminated between sampling locations. Sampling personnel must use disposable gloves and change them between sampling intervals.

Soil and sediment sampling equipment including, but not limited to trowels, beakers, dredges, etc., shall be decontaminated using the following procedures:

- Clean with tap water and laboratory detergent (non-phosphorus) using a brush if necessary to remove particulate matter and surface films. For badly contaminated equipment, a hot water detergent wash may be needed prior to the rinse procedure. Wash the item thoroughly in a bucket of soapy water (tap water). Use a stiff-bristle brush to dislodge any clinging dirt. Disassemble any items that might trap contaminants internally before washing. Do not reassemble until decontamination is complete.
- Rinse thoroughly with tap water.
- Rinse with 10 percent nitric acid if samples for metal analyses will be collected.
- Rinse thoroughly with distilled-deionized water.
- Rinse with 10 percent methanol (pesticide-grade) if samples for organic analyses will be collected.
- Rinse thoroughly with distilled-deionized water.
- Air dry or wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported. After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.
- Collect all rinse waters in a dedicated receptacle and dispose according to site disposal procedures.

The following steps will be followed when decontaminating pumps:

- Pumps should be set-up in the same configuration as for sampling equipment.
- Flush the pump with potable water. Submerge pump intake (or pump if submersible) and all downhole wetted parts (tubing, piping, foot valve) in soapy water.
- Pump a minimum of three pump assembly volumes of soapy water through the entire assembly. Note: If dedicated tubing is used for monitoring wells, the tubing will not need to be decontaminated.

- Any portion of the drill rig, backhoe, etc., that is over the borehole (Kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (soap and high pressure hot water) between boreholes.
- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

Decontamination wastes will be collected and contained unless otherwise directed by onsite procedures. The eventual disposition of these wastes will be determined on a project-specific basis, but may include on -site treatment and/or transport off site to an approved treatment/disposal facility.

7.2 General Cleaning Procedures

One type of cleaning is, "abrasive cleaning." This method works by rubbing and wearing away the top layer of the surface containing the contaminant. The following reviews the available abrasive methods.

- Mechanical** - Mechanical methods include using brushes with metal, nylon, or natural bristles. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushing, and degree of brush contact. Material may also be removed by using appropriate tools to scrape, pry, or otherwise remove adhered materials.
- Air Blasting** - Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, and time of air blasting dictate cleaning efficiency. The method's disadvantages are its inability to control the exact amount of material removed and its large amount of waste generated.
- Wet Blasting** - Wet blast cleaning involves the use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area.

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. The following are acceptable materials used for containing the specified cleaning solutions:

- Soap must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use or a squeeze bottle may dispense it.
- Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.
- De-ionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.
- Organic-free water should be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles or beakers.

- Replace soapy water with potable water.
- All downhole wetted parts must be immersed in the potable water rinse. Pump a minimum of three pump assembly volumes of clean water through the entire assembly.
- Document that decontamination was performed in the groundwater sampling log book.

Additional equipment cleaning and housekeeping procedures are as follows:

- Field analytical equipment which may come in direct contact with the sample or sample media, including, but not limited to water level meters, water/product level meters, pH or specific ion probes, specific conductivity probes, thermometers, and/or borehole geophysical probes must be decontaminated before and after use unless manufacturers instructions indicate otherwise.
- Probes that contact water samples not used for laboratory analyses may be rinsed with distilled water.
- Probes which make no direct contact (e.g. HNu or OVA probes) will be wiped clean with clean paper towels or an alcohol-saturated cloth.
- Document that decontamination was performed in the appropriate logbook.
- Disposable items will be bagged for disposal as general refuse.

8.0 QUALITY ASSURANCE RECORDS

Equipment blanks will be collected from water source for steam-cleaning equipment as quality assurance records. The frequency of collection of equipment blanks from either drilling tools or field sampling equipment shall be specified in the SAP and QAPP for a given project. Documentation in the drillers' logbook shall serve as a QA record of decontamination. The drillers will oversee decontamination procedures to ensure that they have been completed according to the procedures outlined above.

9.0 HEALTH AND SAFETY RECORDS

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods (i.e., the method may react with contaminants to produce heat, explosion, or toxic products). Decontamination methods may be incompatible with clothing or equipment (e.g., some solvents can permeate and/or degrade protective clothing). Also, a direct health hazard to workers can be posed from chemical decontamination solutions that may be hazardous if inhaled or may be flammable.

The decontamination solutions must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods do pose a direct health hazard, measures should be taken to protect personnel or modified to eliminate the hazard.

All site-specific safety procedures should be followed for the cleaning operation. At a minimum, the following precautions should be taken:

- Safety glasses with splash shields or goggles, neoprene gloves, and laboratory apron should be worn.
- All solvent rinsing operations should be conducted under a fume hood or in open air.
- No eating, smoking, drinking, chewing, or any hand-to-mouth contact is permitted.

10.0 REFERENCES

NJDEP, 1988. Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, 1988.

OSHA, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October 1985.

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TABLES

Table 1:	Toxicity Characteristic Leaching Procedure (TCLP) Maximum Concentration of Contamination for the Toxicity Characteristic
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FIGURES

Figure 1:	Investigation-Derived Waste Decision Flow Chart
Figure 2:	Investigation-Derived Waste Decision Flow Chart for PPE
Figure 3:	Investigation-Derived Waste Decision Flow Chart for Solid Materials
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Attachment A: Investigation-Derived Waste Drum Log

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1.0 INTRODUCTION

Investigation-derived wastes (IDW) will be generated during site investigation activities for the Corrective Action/Agreed Order at US Steel - Gary Works (USS). The purpose of this document is to guide the characterization and containerization of IDW as required by 40 CFR, Subpart A, 262.11 - "Hazardous waste determination" and this plan shall be incorporated in all the future remedial investigation work plans for this site. This regulation requires that a person who generates a solid waste as defined in 40 CFR 261.2, must determine whether the waste is a hazardous waste using one of three methods: 1) by generator knowledge (i.e., reviewing *historical information* about the location where the waste was generated; 2) by determining whether the waste is a *listed waste* or is a waste generated in association with a listed waste (40 CFR, 261, Subpart D), or 3) by analyzing the waste using analytical methods to determine if the waste exhibits *characteristics* of a hazardous waste (40 CFR, Subpart C, 261.20).

2.0 INVESTIGATION-DERIVED WASTES

Solids, including Personal Protective Equipment (PPE), and liquids are expected to accumulate from the following activities during investigation and are considered IDW:

SOLIDS:

- Soil cuttings from the drilling of subsurface borings
- Soil cuttings from the installation of additional monitoring wells
- Solids recovered from drums, if any, containing liquid wastes after the liquids are removed and disposed
- Used Personal Protection Equipment (PPE)

LIQUIDS:

- Groundwater from the development and/or purging of monitoring wells
- Water from the decontamination of sampling equipment, tools, machinery, etc.
- Water from the de-watering of test pits or other low-lying areas

Wastes classified as hazardous, or any PPE waste generated from contact with listed hazardous waste, will be shipped to a Treatment, Storage, and Disposal (TSD) Facility, or, if approval is obtained from USEPA, to an onsite Corrective Action Management Unit (CAMU).

If the materials are solid and are classified as non-hazardous or generated from investigation within CAMU or Area of Contamination (AOC) (hazardous or non-hazardous), they will be left in-place. As such, PPE waste will be placed in an appropriate designated drums/containers/dumpsters and will

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be disposed as non-hazardous special waste or as hazardous, based on its generation (See Section 3.4). If the wastes are liquids, compatible with the treatment equipment and discharge approval/NPDES permit modification received from IDEM, they will be transferred to USS process sewer. Otherwise, all liquids will be shipped off-site to a TSD facility.

The hazardous and non-hazardous waste identification and management procedures for PPE, solid and liquid waste are provided in Section 3.0 and Section 4.0. Section 5.0 provides information on potential disposal options for IDW and an additional waste characterization sampling that may have to be performed in order to satisfy offsite disposal facility requirements for both solid and liquid waste.

3.0 MANAGEMENT OF SOLIDS AND PPE GENERATED DURING INVESTIGATION

3.1 Material Generated Within an AOC and/or a CAMU

Any solids generated during an investigation within a designated AOC and/or CAMU may be left in-place regardless of its identification as hazardous or non-hazardous waste materials. See Figures 1, 2 and 3.

3.2 Material Generated Outside of an AOC and/or CAMU

Any solid waste generated outside of AOC and/or CAMU shall be identified by USS personnel and shall be managed according to the procedures outlined in this section and all the applicable requirements of 40 CFR, Parts 261 through 268. Pursuant to 40 CFR, Section 261.2, the generator of any solid waste must determine whether the waste is hazardous or non-hazardous using one of the following two methods outlined in this section.

3.2.1 Historical Information and Listed Wastes

Historical information associated with each investigation location should be assessed before sampling, ideally during the preparation of the work plans. Based on this information, investigation locations judged to generate solids due to the presence of listed wastes would be identified as hazardous waste. Listed hazardous wastes include non-specific sources (i.e., F wastes), specific sources (i.e., K-wastes), and/or discarded commercial chemical products (i.e., P and U wastes). Spill residues of F, K, P, or U wastes, including contaminated soil, water and other debris resulting from the cleanup of the spill are classified as hazardous wastes if they are intended for disposal. All listed hazardous wastes will be containerized and disposed at a TSD Facility to meet the requirements of 40 CFR, Part 261 through 268.

3.2.2 Characteristic Wastes

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Where no information indicates a history of either the use of a hazardous waste or the presence of a listed hazardous waste or historical information regarding the waste is not available then the analytical results from discrete samples collected at the investigation area(s), will be assessed to determine disposal options. In this case record shall be kept of the source of the IDW solids placed in each drum/container from each source area. The analytical data produced to characterize solids reported as a *total* measure of the concentration of an analyte will be used for comparison. This total concentration will be compared to the Regulatory Limit from the Toxicity Characteristic Leaching Procedure (TCLP). If the total concentration is less than 20 times the Regulatory Limit for a solid (Table 1), then the solids that are generated from the investigation will be considered non-hazardous¹.

3.3 Material Generated From Investigation Pits and/or Trenches

Excavation material from investigation test pits and/or trenches will be returned or put back into the excavation zone. If subsequent analysis confirms the presence of constituents of interest in the media above applicable risk screening levels, the requisite corrective measures will be addressed in the final remedy selected for the area of concern.

3.4 Personal Protective Equipment Waste

Personal Protective Equipment (PPE) will be disposed either as hazardous or non-hazardous waste in an appropriate designated drum/container/dumpster based on its generation. PPE, which will be generated from coming into contact with listed hazardous waste will be disposed in a separate drum/container/dumpster designated for hazardous waste and shipped to a TSD Facility. However, PPE generated during the investigation from non-hazardous or characteristic hazardous waste areas will be placed in a separate container and will be managed as non-hazardous special waste. Thus, USS will separate hazardous and non-hazardous PPE for management during any site investigation work.

4.0 MANAGEMENT OF HAZARDOUS OR NON-HAZARDOUS LIQUID WASTE

It is expected that during sampling activities at USS, liquids will be generated. The liquid is anticipated to fall into three (3) categories:

¹ Since TCLP measures the concentration of leachable substances in a solid waste, the units of measure for the Regulatory Limits are shown as mg/L. To determine if the *total* concentrations in mg/Kg in a sample are less than the Regulatory Limits, a factor of 20 will be applied to the sample's analytical result. This factor (i.e., 20) represents the amount of sample (100 grams) to liquid (2000 milliliters) used in the TCLP extraction procedure. If this value is less than 20 times the Regulatory Limits then the waste will pass the TCLP test. The waste can therefore, be disposed in a landfill without treatment or stabilization. This is known as the 20xRule.

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1. Groundwaters from the purging and development of monitoring wells
2. Wastewaters from the decontamination of equipment used in sampling
3. Surface waters or water-in-fill removed during de-watering activities

The disposal options for liquids include disposal by discharge into the on-site process sewer upon an appropriate modification into the USS' NPDES permit or shipment to an offsite TSD Facility. Any liquids that cannot be discharged into onsite process sewers shall be containerized and disposed properly as liquid wastes in accordance with procedures described in Section 4.2. In such events, USS shall keep record(s) of IDW placed in each drum/container from each source area(s) (Figure 4).

4.1 Liquid Wastes - Discharges to the Site Process Sewer

The following steps will be employed to determine the feasibility of disposing liquid wastes in an on-site sewer:

1. Contact the responsible group (both Operations and Environmental Control) to obtain clarification on discharge criteria.
2. If required, and based on the discharge criteria, collect additional samples for analysis.
3. Forward copies of historical data or analytical data for preview to determine the possibility for discharge.
4. Modification into USS NPDES Permit.
5. Arrange disposal dates and times.
6. Schedule pumping from holding tanks or drums to selected sewer system.

4.2 Liquid Wastes – Below MCLs or Risk Based Levels

If bulk liquids generated during pumping are below MCLs or site specific risk based action levels, then the liquids will be pumped back into the well.

4.3 Liquid Wastes – TSD Facilities

In the instances where liquid wastes associated with development and/or purging of specific wells, dewatering of test pits, and equipment decontamination are restricted from disposal in the on-site process sewer system (e.g., wastewaters containing trace levels of mercury). For these types of liquid wastes, the wastes may be disposed at an offsite TSD. All applicable procedures for the disposal of these liquid wastes are found in Section 5.0.

5.0 IDW DISPOSAL OPTIONS

The disposal options for the IDW at USS include the following: 1) disposal to a TSD for hazardous wastes; 2) disposal to the on-site process sewer system (liquid wastes only); 3) disposal for restricted

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wastes (generally liquids) to a TSD or alternate, designated facility; or 4) placement of non-hazardous solid waste to the original sample collection location; 5) placement of any media generated from a test pits and/or trenches back into the excavation zone; or 6) placement of any media to the Corrective Action Management Unit (CAMU) (pending USEPA approval). The procedures for disposal at each of these facilities are described in the following sections.

5.1 Hazardous Wastes to a TSD Facility

All hazardous waste (solid and/or liquid) will be containerized and managed properly at an appropriate TSD Facility in accordance with all requirements at 40 CFR, Part 260 through 268 for disposal.

5.2 Liquids Disposal to the USS Process Sewer

The processes to evaluate whether a liquid waste is acceptable for disposal in the USS process sewers are described in Section 4.0. It should be noted that any solids that have settled in the drums containing liquids, should not be placed in site sewers. The solids should be consolidated (using a shovel) into one or more drums, and characterized using procedures in Section 5.4. If the solids are identified as hazardous, the solids must be handled as hazardous waste and disposed at a TSD Facility. If solids are identified as non-hazardous then solids can be managed as non-hazardous special waste.

5.3 Liquid Waste to TSD Facility

Any liquid wastes that are restricted from being returned to the ground or disposal into on-site process sewer system shall be containerized and send off-site to a TSD Facility. Prior to shipment, if requested by TSD Facility, an additional analysis shall be conducted on a waste as outlined in Section 5.5.

5.4 Waste Placement on USS Property

5.4.1 Disposal of Non-Hazardous waste

Solid wastes that have been classified as non-hazardous may be placed on USS property in the general vicinity of the borings.

5.4.2 Disposal of Waste generated From Test pits and/or Trenches

Any waste, hazardous or non-hazardous, generated from an investigation test pits and/or trenches will be placed back into the excavation zone.

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5.5 Additional Analytical Testing

5.5.1 Waste Profiles

For each drum/container, the analytical data associated with the samples collected for characterization of the site will be evaluated to determine if a the IDW is a hazardous waste. To evaluate the data, a table will be produced that summarizes the drum/container identification, associated sample identifications, and analytical results. The analytical data shown in the table will present the average concentration in mg/kg in a series of several individual samples collected at the site.

To determine if the data identifies a hazardous waste, it will be compared to the Toxicity Characteristic Leaching Procedures (TCLP) regulatory limit (40 CFR 261.24), Table 1. The process to be used is explained in Section 3.2.2 of this document.

5.5.2 TSD Facility Requirements

Generally, all TSDs require that the generator provide a comprehensive summary of analytical data collected from the analysis of the waste, or a list of known characteristics of the waste developed from generator knowledge. This information is typically summarized on a TSD's Waste Profile form and is a requirement of the Facility's RCRA Part B or interim status permit. Profiles itemize the analytical information about a waste stream and provide the TSD with enough information to determine if the waste requires treatment or stabilization prior to disposal. The form must be completed prior to acceptance of a waste. If insufficient analytical information is provided, the TSD has the right to reject the waste and/or require that the generator obtain additional analytical information prior to acceptance.

Table 1 shows the TCLP analysis regulatory limits for various analytes (in mg/L). Liquid waste that cannot be disposed into an onsite sewer system must be disposed at a permitted wastewater treatment facility or a TSD facility. However, the TSD still has the right to review analytical data and accept or reject the waste based on its permit conditions.

2 The analytical data will not represent results from the testing of a composite sample of the solids in the drum.

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Where insufficient data are available to adequately characterize the waste (per 40 CFR, 262.11), or do not meet the minimum analytical requirements for the intended disposal facility, additional samples will be collected. The analytical tests to be performed will be those tests dictated by 40 CFR 262.11, or are those needed to satisfy the disposal company's permit requirements. Some methods that may be required to further characterize the wastes are as follows:

- TCLP (For metals, VOCs, SVOCs)
- PCBs
- Flashpoint (liquid waste only)
- pH (Corrosivity)(liquid waste only)
- Paint filter liquids test
- Reactive cyanide/Reactive sulfide

5.5.3 Sample Collection - Solid Wastes

When required by the disposal facilities, additional samples will be collected from each drum/container to provide a consistent analytical tests. These solid samples will be collected using either a trowel or Auger (SW-846, Chapter 9, Sampling Plans, 1986). A trower consists of a "tube cut in half lengthwise with a sharpened tip that allows the sampler to cut into sticky solids and loosen soil. A trower samples moist or sticky soils with a particle diameter of less than one-half the diameter of the trower." Augers consist of "sharpened spiral blades attached to a hard metal central shaft." An auger samples hard or packed solid wastes or soils." Both sampling devices will be fabricated from stainless steel.

The following specific sampling procedures will be employed to collect samples from the drums at USS:

1. Use protective clothing, gloves, etc. and observe required sampling safety precautions³.
2. Position the drum so that container lid is up; (do not obtain solid samples with bungs); if a solid sample is taken from a drum with a bung, the disposal company must be notified.
3. Slowly loosen the container lid and allow any gas pressure to be released.
4. Remove the lid and insert the trier or auger; ensure that the sampler is clean and operating correctly before inserting in the waste; decontamination procedures for the device will be those described in the USS Sampling Plan.
5. Insert the trier or auger until the bottom of the waste container is contacted.
6. Remove the sampler device and extrude the contents into a stainless steel mixing pan.
7. Repeat this process twice more inserting the sampling device in two (2) new locations in the drum; a minimum of three (3) subsamples (consisting of the entire height of the drum) should be collected from each drum.
8. Homogenize the soil in the stainless steel mixing pan with a stainless steel trowel.

3 Personnel will wear either Level D+ or Level C PPE during drum sampling.

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9. Subsample the homogenized soil and place an aliquot in a container appropriate for the analysis.
10. Cap the container; decontaminate the sampling device per guidance in this plan.
11. The laboratory performing the analytical testing will comply with the Quality Assurance Project Plan (QAPP).

The analytical data generated from this additional testing will be assessed in comparison to the actual regulatory limits (Table 1). If any limit is exceeded, the waste is considered hazardous and must be disposed at a TSD. If no analyte concentration is exceeded, then USS will not remove waste to an offsite location, but place the waste back in the original site location. A copy of the original analytical report for the waste disposal characterization must be provided to the disposal company for evaluation.

5.5.4 Sample Collection - Liquid Wastes

For collection of liquid wastes from a drum, a Coliwasa will be used. A Coliwasa permits the representative sampling of multiphase wastes of a wide range of viscosity, corrosivity and solids content. The sampling tube consists of a 5-ft by 1 and 5/8 inch inner diameter translucent plastic (PVC) or glass (borosilicate) pipe. The closure-locking mechanism consists of a short-length channelled aluminum bar attached to a stopper rod made from Teflon. The rod has an adjustable swivel that can lock the unit opened or closed during the sampling stage. For USS, disposable glass devices will be used.

The following specific sampling procedures will be employed to collect samples from the drums:

1. Use available protective clothing, gloves, etc. and observe required sampling safety precautions.
2. Position the drum so that the open-top lid, or the bung side is up. (Drums with the bung on the end should be positioned upright; drums with bungs on the side should be laid on its side, with the bungs up.)
3. Allow the contents of repositioned drums to settle for at least one hour. Slowly loosen the latches for an open-top container or the bung with a bung wrench, allowing any gas pressure to be released; remove the container lid.
4. Make sure the Coliwasa sampler is clean and operating correctly before immersing in the waste liquid; decontamination procedures for the device will be those described in the USS Work Plan; adjust the stopper mechanism to ensure a tight closure.
5. Put the Coliwasa in the open position and slowly lower the sampler into the liquid waste; lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same; if the level of the liquid in the tube is lower than outside the sampler, then the sampling rate is too fast and will result in a non-representative sample.
6. When the sampler hits the bottom of the container, push the tube down to close the Coliwasa,

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- and lock.
7. Slowly withdraw the Coliwasa from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag.
 8. Discharge the sample into a sample container by slowly opening the sampler.
 9. Cap the container; decontaminate or dispose of the Coliwasa and the rags, per guidance in this plan; then ship the samples to the selected analytical laboratory.
 10. The laboratory performing the analytical testing will comply with the USS QAPP.

TABLE 1
Toxicity Characteristic Leaching Procedure (TCLP)
Maximum Concentration of Contaminants

EPA Hazardous Waste No.	Contaminant	Regulatory Limit (mg/L) use for IDW liquids	"20xRule" Concentration (mg/Kg) use for IDW solids
D004	Arsenic	5.0	100.0
D005	Barium	100.0	2000.0
D018	Benzene	0.5	10.0
D006	Cadmium	1.0	20.0
D019	Carbon Tetrachloride	0.5	10.0
D020	Chlordane	0.003	0.06
D021	Chlorobenzene	100.0	2000.0
D022	Chloroform	6.0	120.0
D007	Chromium	5.0	100.0
D023	o-Cresol	200.0*	4000.0
D024	m-Cresol	200.0*	4000.0
D025	p-Cresol	200.0*	4000.0
D026	Cresol	200.0*	4000.0
D016	2,4-D	10.0	200.0
D027	1,4-Dichlorobenzene	7.5	150
D028	1,2-Dichloroethane	0.5	10.0

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TABLE 1
Toxicity Characteristic Leaching Procedure (TCLP)
Maximum Concentration of Contaminants

EPA Hazardous Waste No.	Contaminant	Regulatory Limit (mg/L) use for IDW liquids	"20xRule" Concentration (mg/Kg) use for IDW solids
D029	1,1-Dichloroethylene	0.7	14.0
D030	2,4-Dinitrotoluene	0.13**	2.6
D012	Endrie	0.02	0.4
D031	Heptachlor	0.008	0.16
D032	Hexachlorobenzene	0.13**	2.6
D033	Hexachlorobutadiene	0.5	10.0
D034	Hexachloroethane	3.0	60.0
D008	Lead	5.0	100
D013	Lindane	0.4	8.0
D009	Mercury	0.2	4.0
D014	Methoxychlor	10.0	200
D035	Methyl ethyl ketone	200.0	4000
D036	Nitrobenzene	2.0	40.0
D037	Pentachlorophenol	100.0	2000
D038	Pyridine	5.0**	100
D010	Selenium	1.0	20.0
D011	Silver	5.0	100
D039	Tetrachloroethylene	0.7	14.0
D015	Toxaphene	0.5	10.0
D040	Trichloroethylene	0.5	10.0
D041	2,4,5-Trichlorophenol	400.0	8000

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TABLE 1
Toxicity Characteristic Leaching Procedure (TCLP)
Maximum Concentration of Contaminants

EPA Hazardous Waste No.	Contaminant	Regulatory Limit (mg/L) use for IDW Liquids	"20xRule" Concentration (mg/Kg) use for IDW solids
D042	2,4,6-Trichlorophenol	2.0	40.0
D017	2,4,5-TP (Silvex)	1.0	20.0
D043	Vinyl Chloride	0.2	4.0

Table Note:

- * When -o-, -m-, p-Cresol concentrations cannot be differentiated, the total Concentration shall be reported.
- ** The quantitation limit is greater than the regulatory limit. The quantitation limit, therefore, becomes the regulatory limit.

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Figure 1
Investigation Derived Waste (IDW) Decision Flow Chart

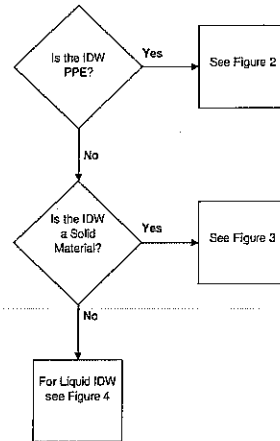


Figure 1

Figure 2
Investigation Derived Waste (IDW) Decision Flow Chart for PPE

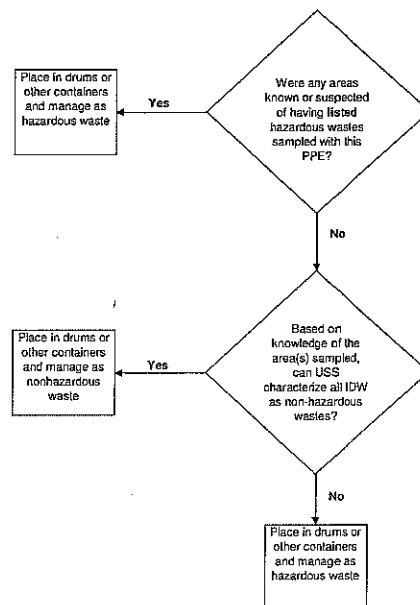


Figure 2

Figure 3

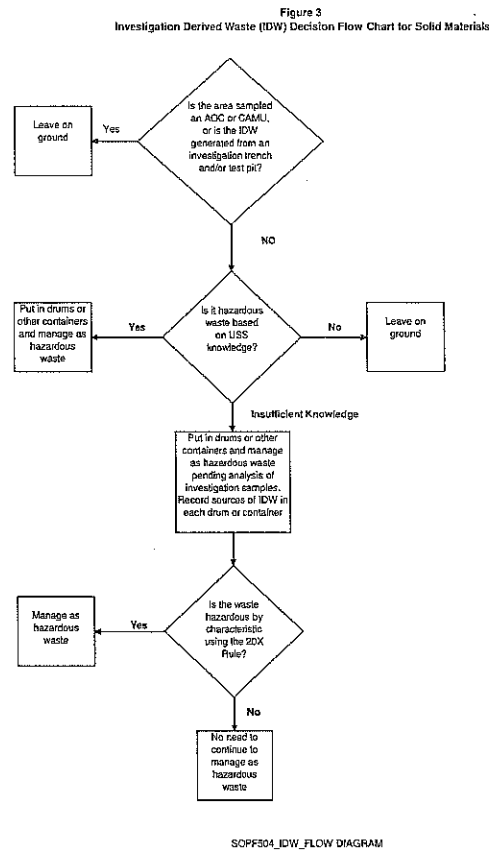


Figure 4

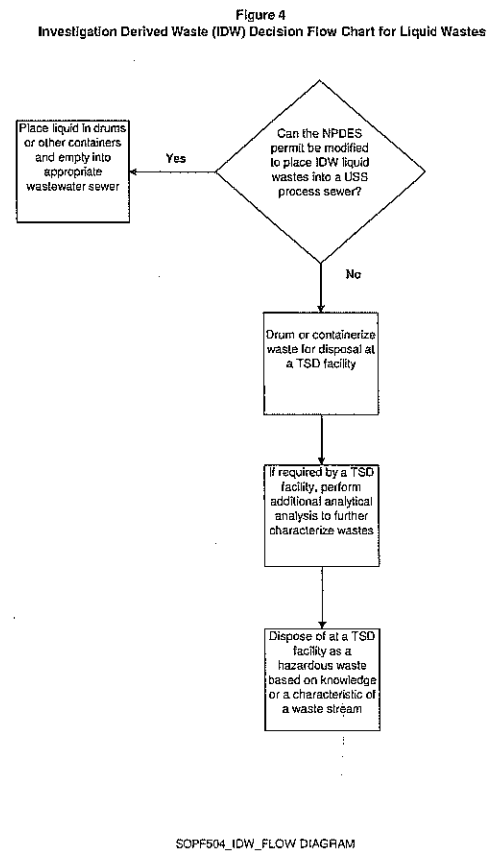


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Attachment 1: Quality Assurance Project Plan Acknowledgement Form

NOTE: THIS SOP IS A GENERAL DOCUMENT. SITE-SPECIFIC CONDITIONS MAY WARRANT CHANGES IN PROCEDURES AND APPLICATIONS. FIELD STAFF SHALL DOCUMENT ACTUAL PROCEDURES IN THE APPROPRIATE FIELD LOGBOOK.

1.0 PURPOSE

This procedure outlines the general organization for sample collection, sample identification, record keeping, field measurements, and data collection. These guidelines are followed to ensure that the activities used to document sampling and field operations generate standardized information and identifications.

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures, which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in accordance with the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Drilling Inspector - It is the responsibility of the drilling inspector to follow these procedures, or to follow documented, project specific procedures as directed by the Field Team Leader and/or the Project Manager. The Drilling Inspector is responsible for the proper acquisition of rock cores and subsurface soil samples.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of samples.

Project Manager - The Project Manager checks all work performance and acknowledges that the applicable tasks required by this procedure have been performed. This will be accomplished by reviewing and signing the field log books.

Equipment Manager - The Equipment Manager (optional) is responsible for ensuring that all field equipment used for the project is in working condition. He coordinates all repairs on broken or inoperative equipment. Also he/she is responsible for labeling client-owned equipment.

Project Health and Safety Coordinator - The Project H&S Coordinator works at the site and is responsible for ensuring that project personnel use safe field procedures and are equipped with proper safety equipment. He interacts with the Project Manager, Field Coordinator, and Corporate H&S on environmental monitoring programs and decontamination processes.

Quality Assurance Manager - The QA Manager verifies the implementation of all quality assurance program requirements for the project. He/She provides quality assurance training to project staff and interacts with the Project Manager on technical problems related to sampling methods and instrumentation. He/She verifies that proper sample containers, preservation, and container cleaning techniques are specified and followed during all phases of the project.

Data Management Coordinator - The Data Management Coordinator is responsible for overseeing and implementing the daily data management requirements of a project. He/She coordinates all data management aspects of a project within the data management group from project inception to close-out.

5.0 INTERFERENCES AND POTENTIAL PROBLEMS

Communication is the most effective means of eliminating potential problems during field work. Strong communication between field team members and office staff prevent errors in field assignments and promote safety. Adequate site preparation and utility clearance procedures must also be performed. Utility clearance procedures are included in SOP F709 (site utility clearance procedures).

6.0 EQUIPMENT AND SUPPLIES

Potential equipment needed for field assignments may include:

- Soil probing machine (e.g., Geoprobe)
- Conventional drill rigs (e.g., Rotasonic, split-spoon)
- Hand auger, trowel, shovel
- Stainless steel spoons/bowls
- Safety equipment (hardhat, steel-toed shoes, Tyvek coveralls, safety glasses)
- Explosive gas and/or oxygen meter
- PID or PID/FID Meter
- Outer gloves, inner gloves
- Field data sheets
- Decontamination equipment (methanol, water, soap, distilled water, brushes)
- Paper towels
- Maps/plot plan
- Safety equipment
- Compass/Global Position System (GPS)
- Tape measure
- Survey stakes, flags
- Camera and film
- Logbook/waterproof pen

7.0 PROCEDURES

7.1 Pre-mobilization

The Project Manager shall provide copies of the Project QAPP and Project SAP to sampling personnel for use in the field. The QAPP should contain all applicable SOPs and clean copies of the data recording forms. Sampling Personnel must complete the QAPP acknowledgement form (Attachment 1) prior to commencement of work and provide the document to the QA Manager.

7.2 Mobilization

All equipment is to be checked on a daily basis, at a minimum, prior to beginning field work, to verify that it is operational and calibrated before initiation of field activities.

7.3 Daily Site Operations

All decisions concerning sampling, equipment problems, changes in strategy, public relations, H&S, site visitors, and disciplinary problems will originate from the Project Manager or his/her appointee (e.g., Field Coordinator, Project QA Manager).

7.4 Field Documentation

All project activities will be recorded each day in the log book according to SOP F303, Use and Maintenance of Field Log Books. This will include a minimum of the following:

- Project Number
- Project Name
- Page number
- Date (mm/dd/yyyy)
- Time (2400 hr.)
- A brief description of each site activity
- Site visitors

At the close of each day's field activities, the Field Coordinator shall prepare the daily Activity Log, summarizing the activities that occurred during the day (Attachment 2).

The Field Coordinator shall ensure that the sampling procedures specified in the QAPP, SAP, and SOPs are followed during all phases of sampling activities at the site. For each sampling activity, field personnel shall record the information required by the SOP on the data sheets provided and/or in the field log book. If deviations from the sampling procedures are required, an accurate description of the changes (and reasons for them) shall be recorded in the field log book.

8.0 QUALITY ASSURANCE RECORDS

Where applicable, Field Test Boring Records and Test Boring Records will serve as the quality assurance records for subsurface soil samples, rock cores and new surface soil samples collected with a hand or power auger. Observations shall be recorded in the Field Logbook or PDA as described in SOP F303. Chain-of Custody records shall be completed for samples collected for laboratory analysis as described in SOP F302. Once the investigation is completed, the field logbook (and/or copies) becomes part of the Quality Assurance Record and must be placed in the Evidence File for the project.

9.0 HEALTH AND SAFETY

A H&S program for drilling will prevent injury to workers and observers; reduce any negative impact on the community and the environment; eliminates damage to surface and subsurface and structures, and alleviates and client concerns over safety/expertise. The H&S program must pre-qualify the drillers considering previous safety performance (TRIR, EMR, etc.); training and experience of personnel; age and condition of required equipment; medical and substance abuse surveillance; proof of insurance; licenses and registrations; and its references.

10.0 REFERENCES

U.S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U.S. EPA, Environmental Services Division, Athens, Georgia.

Attachment 1: U. S. Steel (Gary Works) Facility-wide Quality Assurance Project Plan (QAPP) Acknowledgment Form

QUALITY ASSURANCE PROJECT PLAN ACKNOWLEDGEMENT FORM

Field Activity: _____

Project Number: _____

Description of Activities to be Performed: _____

Applicable Work Plan or Scope of Work: _____

Applicable Standard Operating Procedures (SOPs):

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

13. _____

14. _____

15. _____

I acknowledge that I have reviewed the appropriate SOPs (above) from the U. S. Steel – Gary Works Facility Wide QAPP (most current edition) as they pertain to the field activities I am to conduct.

Name: _____

Signature: _____

Date: _____

Attachment 2: U. S. Steel (Gary Works) Daily Activity Log Sheet



DAILY FIELD LOG

DATE: _____

DAY: M T W Th F

PROJECT: _____

PROJECT NUMBER: _____

PROJECT MANAGER: _____

URS STAFF: _____

WEATHER	SUNNY	OVERCAST	RAIN	SNOW
TEMP	TO			
WIND	STEEL	MODERATE	HIGH	
HUMIDITY	DRY	MODERATE	HIGH	

SUBCONTRACTORS ON SITE: _____

EQUIPMENT ON SITE: _____

WORK PERFORMED

HEALTH & SAFETY LEVELS AND ACTIVITIES: _____

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS): _____

PROBLEMS ENCOUNTERED: _____

SPECIAL NOTES: _____

COMPLETED BY _____ REVIEWED BY _____ DATE _____

